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# Sand and Gravel Resources of the Opapimiskan Lake Area District of Kenora (Patricia Portion)

by

Staff of the Engineering and Terrain Geology Section
Ontario Geological Survey

1986

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V.G. Milne, Director
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## FOREWORD

The Opapimiskan Lake Area contains numerous sand and gravel deposits which were laid down during glacial times. This report and its accompanying maps delineate these deposits and provide additional information regarding their thickness, geological character and suitability for use as construction aggregate. The report also indicates which deposits possess the greatest potential for resource utilization.

The report supplies valuable information which will be beneficial in resource planning and possible future development of this remote area of northwestern Ontario.

V.G. Milne, Director
Ontario Geological Survey

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Project Supervisors: E.V. Sado and I. Szoke

Field Work and Report by: G.R. Jones

Compilation and Drafting by: Staff of the Aggregate Assessment Office

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**Maps**
**(back pocket)**

1 - Distribution of Sand and Gravel Deposits, Opapimiskan Lake Area, Scale 1:50 000.
2 - Selected Sand and Gravel Resource Areas, Opapimiskan Lake Area, Scale 1:50 000.

**ABSTRACT**

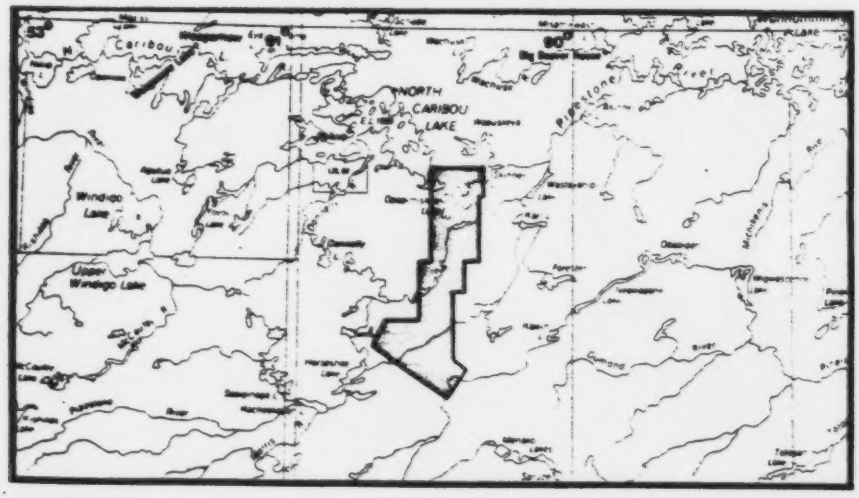


**Figure 1** - Key Map Showing the Location of the Opapimiskan Lake Area, Scale 1:1 584 000.

This report presents the results of a sand and gravel inventory in the Opapimiskan Lake Area in the District of Kenora, Patricia Portion. Six Resource Areas of Primary Significance have been selected for possible resource protection. These areas are considered the best suited for extractive development within the report area. Selected Sand and Gravel Resource Area 1 consists of five deposits which form part of the Agutua Moraine. It possesses the largest potential resources of quality aggregate in the area. The esker and ice-contact deposits which form Primary Resource Areas 2 to 6 are also valuable potential sources of quality aggregate. The six Resource Areas occupy 23,500 acres (9500 ha) available for extraction and contain total resources of 2270 million tons (2060 million tonnes). Several Secondary Resource Areas have also been selected for possible resource protection. Although these deposits are generally not as significant as the Primary Resource Areas, they add considerably to the report area's resource base.

Generally the resources of sand and gravel delineated in the vicinity of Opapimiskan Lake and the Windigo Lake Road appear adequate to meet future needs. Resources in the central part of the study area, however, are scarce. If major road building and construction activities are undertaken in this area, aggregate would probably have to be transported from aggregate rich areas to the south or north. Field observations and quality testing indicate the aggregate in the report area is hard and durable and suitable for most usual aggregate applications including use in structural concrete.

# SAND AND GRAVEL RESOURCES OF THE OPAPIMISKAN LAKE AREA[1]

## INTRODUCTION

The sand and gravel resources of the Opapimiskan Lake Area were investigated by a two-man field party in the summer of 1984. This investigation is part of a 3-year integrated study of the North Caribou Lake area involving work by the Staff of the Precambrian Geology Section, the Engineering and Terrain Geology Section, and the Mineral Deposits Section of the Ontario Geological Survey (Breaks et al. 1984). The purpose of this integrated study, known as the Opapimiskan Lake Project, is to provide an updated and expanded database to assist mineral exploration and potential mine development in the area. Recent mineral exploration activity in the vicinity of Opapimiskan Lake has created wide interest in the gold potential of the region.

The aggregate assessment component of this integrated study has been undertaken to identify resources of sand and gravel suitable for road-building and general construction purposes in the Opapimiskan Lake Area. This information would be especially valuable if mine development occurs in this area. Significant quantities of aggregate would be necessary for construction of mine shafts, mills, all-weather access roads, and possibly for mine backfill. The information portrayed in this report also has important value for inclusion in planning strategies.

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## LOCATION AND ACCESS

The report area is located in a remote area of northwestern Ontario, approximately 50 miles (80 km) north of the community of Pickle Lake in the Patricia Portion of the District of Kenora. The area straddles the route of a winter road running south from Opapimiskan Lake to the gravel-surfaced road leading to Pickle Lake. The study area is covered by the Donnelly River (53 B/10), Forester Lake (53 B/8), Kecheokagan Lake (53 B/2), Mawley Lake (53 B/7), Menako Lakes (53 B/1) and Opapimiskan Lake (53 B/9) map sheets of the National Topographic System, at a scale of 1:50 000.

Access to the southern part of the study area is provided by an all-weather road (Windigo Lake road) extending from Pickle Lake to Windigo Lake. Windigo Lake road and Opapimiskan Lake are linked by a recently constructed winter road. This winter road was constructed to service mine exploration at the Musselwhite Gold Property near the southern shore of Opapimiskan Lake. Other than by way of the winter road, access to the central and northern parts of the report area is provided by float- or ski-equipped aircraft from Pickle Lake. The area is also accessible using watercraft along river and lake systems.

## PHYSIOGRAPHY AND SURFICIAL GEOLOGY

The report area lies within the Canadian Shield and is part of the Severn Upland division of the James physiographic region (Bostock 1969). The terrain in the region is characteristically flat or gently rolling. Glacial and post-glacial materials form much of the area's ground surface, although bedrock outcrop is common in many localities. Extensive areas of outcrop exist in the central part of the report area and northwest of Opapimiskan Lake. The early Precambrian bedrock in the area consists

dominantly of granitic rocks and a belt of supracrustal rocks ('greenstone' belt) trending northeast to southwest in the vicinity of Opapimiskan Lake. These rocks have been described by Andrews et al.(1981), Sage and Breaks (1982), Sage et al. (1973a, 1973b), Satterly (1941), and Thurston et al. (1979). Detailed bedrock geology mapping of the eastern part of the greenstone belt has recently been completed by Bartlett et al. (1985) as part of the Ontario Geological Survey's integrated study of the area (see introduction). For further information on the bedrock geology of the area, the reader is referred to the above reports and maps.

The deposition of glacial sediments in the report area is related to the last major advance and withdrawal of a continental ice sheet during the Late Wisconsian Substage of the Pleistocene Epoch, informally known as the 'Great Ice Age'. The surficial geology of the area has been mapped at a reconnaissance level and the glacial history has been discussed by Prest (1963). P.F. Finamore of the Engineering and Terrain Geology Section, Ontario Geological Survey, Ministry of Northern Development and Mines has mapped the Quaternary geology of the area at a scale of 1:50 000 as part of the aforementioned integrated study. The maps will be published during 1986. The aggregate potential of the area has previously been described on a regional scale by Sado (1976).

A stony, silty, fine sand till was deposited over large sections of the report area by ice which advanced from the northeast (Breaks et al. 1984; Prest 1963; Satterly 1941). The till occurs as a thin veneer over bedrock, as slightly rolling to hummocky ground moraine and as moraine ridges. Generally, in the central part of the report area and northeast of Opapimiskan Lake the till thinly overlies bedrock with localized patches of thicker ground moraine. An almost continuous cover of ground moraine, including a prominent end-moraine and several minor moraines, exists in

the area northwest of Barrigar Lake and southeast of Opapimiskan Lake. The prominent end-moraine parallels the north shore of Zeemel Lake and rises in excess of 100 feet (30 m) above the surrounding landscape. The till within these moraines was probably deposited during temporary halts of the retreating ice sheet. Pockets of sand and gravel may be present locally within the moraines.

The till in the area is usually mantled by a layer of sand, gravel and boulders (boulder lag) formed by reworking of the till by wave action in a glacial lake (Breaks et al. 1984; Prest 1963). Boulders in excess of 2 feet (0.6 m) in diameter are common on the surface of till deposits. This surficial boulder concentration is characteristic of most deposits containing coarse granular materials in the area.

The topography of the southern part of the report area is dominated by the presence of the Agutua Moraine (Prest 1963) which is a major glacial feature in northwestern Ontario. This northwest- to southeast-trending moraine is approximately 2.5 to 3 miles (4 to 5 km )wide in the area and rises up to 100 feet (30 m) above the surrounding terrain. In contrast to the moraines previously discussed, the Agutua Moraine consists predominantly of stratified sand and gravel. The moraine has been subdivided into two distinct units within the report area. The southern unit is a relatively flat plain of deltaic origin deposited in a glacial lake. The relief is more variable in the northern unit and the material shows little evidence of modification by lake action (Prest 1963). Steep slopes mark the northern and southern limits of the moraine and in some localities, the deltaic sediments in the moraine overlie older esker and ice-contact materials. The Agutua Moraine represents the largest potential source of sand and gravel in the report area.

Eskers form segmented, sinuous ridges in the report area. They were deposited by meltwaters flowing in tunnels under the ice or in re-entrants in the ice. The eskers trend in a general north-south or northeast-southwest direction and have local relief ranging from 15 to over 100 feet (5 to over 30 m). Major esker systems are located south and east of Opapimiskan Lake and east of the Pipestone River. Undifferentiated ice-contact stratified drift deposits are often associated with the esker systems. They are usually complex features whose origin can be attributed to a variety of depositional environments. A hummocky and kettled topography commonly typifies the ice-contact deposits. Both the esker and ice-contact deposits consist of stratified sand and gravel, and are good potential sources of aggregate. Reworking of these deposits by glacial lake waters has often resulted in the formation of a coarse, surficial boulder lag and associated wave-cut terraces.

As the ice margin retreated northward, waters of proglacial Lake Agassiz covered the report area (Teller et al., 1983). In the deeper waters of this lake, glaciolacustrine plain sediments were deposited. These sediments generally consist of fine to medium sand, although in certain localized areas, silt and clay was observed. The glaciolacustrine plain deposits usually occupy low-lying areas and additional quantities of these sediments may exist beneath the swamps in the report area. North of the Agutua Moraine, along the Pipestone and Pineimuta Rivers, glaciolacustrine deltas were deposited. These deposits generally contain finer material than the deltaic sediments associated with the Agutua moraine and consist mainly of medium sand. In the shallow waters of the lake, pre-existing glacial deposits were reworked by wave action.

After the waters of glacial Lake Agassiz drained, the deltaic and glaciolacustrine plain sands became susceptible to postglacial wind erosion and transport. Deposits of eolian sand occur mainly in the form of parabolic and longitudinal dunes. Dune sand is especially abundant in the area east of the Pipestone River in the southern part of the study area. The dunes in this area may attain heights of over 20 feet (6 m). Muskeg is common in depressions between the dunes.

The deposition of alluvium and the development of numerous swamps has also modified the physiography of the study area. Alluvium occurs along the course of existing creeks and rivers. Muskeg swamps occur extensively in low-lying areas throughout the report area.

**EXTRACTIVE ACTIVITY**

At the time of field investigation, sixteen pits were identified in the report area. These pits have been opened on a demand basis to supply road-construction materials for the development of Windigo Lake road and the winter road. These extractive sites were at various stages of development. The pits opened along the winter road had recently been worked while many of the sources along Windigo Lake road had been inactive for a period of time. Most of the pits are less than 5 acres (2 ha) in size and less than 20 feet (6 m) in depth.

Application of aggregate along the winter road has occurred mainly in close vicinity to existing pits. Much of the base of the road consists of the naturally occurring materials such as muskeg, till and bedrock. If this road is

to be upgraded for all-weather use, considerable quantities of aggregate would be required. Such upgrading would likely occur if mineral exploration in the area leads to mine development. Great interest in the gold potential of the 'greenstone' belt in the vicinity of Opapimiskan Lake and the surrounding area has been sparked by recent exploration activities (Breaks et al., 1984; Janes and Huggins 1985). During the 1984 field season, a decline was being sunk to further assess the gold reserves in the Musselwhite Property along the southern shore of Opapimiskan Lake. In addition to road-construction material, future mine development would require significant amounts of aggregate for the construction of mine shafts and mills, and possibly for mine backfill.

**AGGREGATE QUALITY AND SUITABILITY**

During field investigation seventeen samples were taken from existing pit faces, shallow test pits, and sections along rivers and roads. These samples were analyzed for grain size distribution, the results of which are portrayed in Figures 2a to 7b. From these figures it can be determined how well the unprocessed sampled material meets the requirements for several products according to the specifications of the Ontario Ministry of Transportation and Communications. Although the gradation curves vary substantially from sample to sample, many of the curves indicate that the material has a tendency to be very clean (ie. lacks fines). The material is so clean, in some samples, that fines may have to be added to act as a binder to ensure proper compaction of this material when used for road construction.

Five of the samples were tested by the Soils and Aggregates Section, Engineering and Materials Office, Ontario Ministry of Transportation and Communications. In addition to grain size analysis, three aggregate quality tests were performed. The results of these tests are portrayed in Appendix E and include absorption and magnesium sulphate soundness tests, along with petrographic analysis. The tests indicate that the aggregate in the report area is of high quality and suitable for such high specification uses as concrete and hot-laid asphalt. Only very minor amounts of undesirable lithologies, such as chert and highly weathered clasts were noted in the samples. The general high quality of the aggregate in the area, as demonstrated by test data, is supported by field observations.

## SELECTED SAND AND GRAVEL RESOURCE AREAS

Map 1 indicates the areas which contain granular materials. Many of these potential resource areas have limited value because of the restricted amount of available resources and/or the predominance of fine sand. Consequently, only the most significant sources are suggested for possible resource protection.

The sand and gravel deposits selected for possible resource protection in the study area are shown on Map 2. Six areas consisting of moraine, glaciolacustrine delta, esker, and ice-contact deposits have been selected as Sand and Gravel Resource Areas of Primary Significance. These Primary Resource Areas have an estimated 23,500 acres (9500 ha) currently available for extraction and contain granular resources of approximately 2270 million tons (2060 million tonnes). In addition, several deposits which provide alternate sites for extractive development have been selected at the secondary level.

The sand and gravel deposits are not evenly distributed throughout the report area, but are concentrated in the north and south. In the south, the Agutua Moraine constitutes the major source of aggregate. Several ice-contact deposits and a series of esker ridges have also been selected at the primary level in this area. Three Primary Resource Areas consisting of esker and associated ice-contact deposits contain significant aggregate resources in the north. Sand and gravel sources are scarce in the central part of the area which is underlain predominantly by bedrock, till and muskeg. If the winter road is to be upgraded to all-weather use in this area, sand and gravel would probably have to be transported from aggregate rich areas in the north and south.

Pits and exposures along rivers and roads constitute the main sources of subsurface information in the report area. Observations made of the surficial material and the sediments exposed by test pitting and soil probing techniques provide additional sources of data. These sources of information, together with knowledge of the geological character and topography of the particular landform, form the basis on which deposits are assessed. Detailed subsurface investigation, however, is recommended prior to extractive development to determine the quality of the aggregate at depth and to delineate specific areas best suited for extractive development within the deposits.

In many instances, the depth of sand and gravel in the Selected Resource Areas may exceed 100 feet (30 m) as indicated by topographic relief. These depths often do not reflect the actual depth of extraction because of economic and engineering considerations. Also, the quality of the aggregate may vary at depth. As a result, the average deposit thickness used in resource tonnage calculations is based on more conservative depth estimates.

**SELECTED SAND AND GRAVEL RESOURCE AREA 1**

Selected Sand and Gravel Resource Area 1 consists of five deposits which form part of the Agutua Moraine. This prominent moraine trends northwest to southeast across the southern part of the project area. It represents the area's largest potential source of sand and gravel. The moraine has been subdivided into two distinct units, Areas 1a and 1b.

The southernmost unit has been designated as Area 1a. The area is relatively flat, reflecting deposition in a glacial lake. This flat terrain is dissected in several localities by north-south trending spillway valleys. Steep slopes mark the area's southern boundary. Road cuts and pits along Windigo Lake road represent the major sources of subsurface information in Area 1a. Sediments ranging from coarse gravel to medium sand are exposed along this road. The material is characteristically very clean and well stratified.

Four pits have been opened in Area 1a. Faces in pit no. 8 are between 20 and 30 feet (6 and 9 m) high, exposing medium to coarse gravel. The gravel appears to be coarse enough for crushing purposes. Pit nos. 6, 7 and 16 are shallow sources with faces less than 4 feet (1.2 m) high. Fine to medium gravel is exposed in these pits and was sampled from pit no.6. The sample contained 56 percent gravel, 43 percent sand and 1 percent fines (Figure 2a). Possible uses of the aggregate include granular base course as well as concrete sand and some asphaltic sand products. The material is very clean and it may be necessary to add fines to ensure proper compaction of the aggregate.

The northern part of the moraine has been designated as Area 1b. The area exhibits a hummocky topography and several pronounced ridges are evident. This part of the moraine has not been reworked extensively by glacial lake waters. The northern boundary of the moraine is irregular and marked by steep slopes. A subdued ridge with local relief generally less than 20 feet (6 m) forms the southern boundary of Area 1b.

The sediments exposed in Area 1b tend to be more variable in texture than those in Area 1a. In parts of Area 1b, clean, well stratified fine to coarse gravel is widely distributed on the surface. In other areas sand is the predominant surficial material. Such is the case along the bush road which branches off Windigo Lake road east of the Pipestone River. Coarse gravel and boulders cover ridges located north of pit No. 11 and large erratics are common on the surface in some localities. In one eight-foot (two-metre) exposure along Windigo Lake road at the western boundary of the report area the aggregate contains a relatively high content of fines. This section has been cut into the ridge which forms the southern boundary of Area 1b and exposes till over gravely medium to coarse sand and silty very fine sand. Till may also underlie other parts of Area 1b (Prest 1963).

Sediments exposed in pits developed in Area 1b range from medium to coarse sand in pit no. 9 to gravel in pit nos. 10 and 15. In pit no. 10, the gravel is concentrated in the upper 2 feet (0.6 m) and is underlain by 3 to 6 feet (1 to 2 m) of clean medium to coarse sand. A sample from the upper gravel layer contained 44 percent gravel, 55 percent sand and 1 percent fines (Figure 2a). Faces in pit no. 15 reveal 10 to 12 feet (3 to 4 m) of sandy gravel. This material was sampled and contained 54 percent gravel, 45 percent sand and 1 percent fines (Figure 3a). The aggregate is likely suitable for pit-run use and is a

potential source of crushable gravel. Sand control would probably be required for crushing.

Resource Area 1 has been classified overall as a gravel source as it contains many areas which are considered to have high potential for locating reserves of quality gravel. Nevertheless, there also exists substantial areas where sand is the dominant material. This sandy material is suitable for lower grade aggregate uses. The gravel in some localities may also represent a surficial lag layer and overlie predominantly sandy aggregate. This relationship was observed in road-side exposures near the Pineimuta River and between pit nos. 8 and 9. Near the river 3 to 4 feet (1 to 1.2 m) of clean, fine to medium gravel overlies 12 to 16 feet (4 to 5 m) of clean, medium sand. Therefore, detailed subsurface investigation is recommended to delineate areas with the highest potential for extractive development. Detailed investigation would be especially important in Area 1b because of the greater variability of sedimentation.

Resource Area 1 totals 21,900 acres (8900 ha). Cultural setbacks and previous extraction reduce the area currently available to 21,300 acres (8600 ha). Assuming an average deposit thickness of 40 feet (12 m), available resources are estimated to be 2130 million tons (1930 million tonnes). The Resource Area is readily accessible via Windigo Lake road.

**SELECTED SAND AND GRAVEL RESOURCE AREA 2**

An ice-contact deposit located along Windigo Lake road, east of the Pipestone River, has also been selected at the primary level of significance. The northern part of the feature consists of a ridge which rises 50 feet (15 m) above the surrounding moraine sediments. Shallow test pits excavated in this ridge exposed fine to coarse gravel with a coarse sand matrix. Numerous boulders were observed on the

surface of the ridge. The southern part of the deposit exhibits a more subdued relief as it has been modified by glacial lake waters. In general, the material in Resource Area 2 appears well suited for use as pit-run aggregate and is a potential source of crushed stone. Some oversize material is present and may require removal or crushing.

Resource Area 2 occupies 110 acres (45 ha), of which 100 acres (40 ha) are considered available for extraction. Assuming an average deposit thickness of 30 feet (9 m), available resources are approximately 8 million tons (7 million tonnes). Windigo Lake road provides access to the deposit.

**SELECTED SAND AND GRAVEL RESOURCE AREA 3**

Eight esker segments located east of the Pipestone River in the southern part of the report area are included in Selected Sand and Gravel Resource Area 3. The eskers have local relief varying from 30 feet (9 m) to over 100 feet (30 m) and are often flanked by kettle depressions. Coarse gravel and large boulders are exposed on the surface of these ridges.

Subsurface data are lacking for the Resource Area, however, a cut along Windigo Lake road in the southernmost esker segment exposes 12 feet (4 m) of fine to coarse gravel with abundant oversize clasts. This material was sampled and contained 69 percent gravel, 30 percent sand and 1 percent fines (OP-SS-12; Figure 7a). Possible uses of the aggregate include both pit-run and crusher-run products. A primary crusher would be beneficial for utilizing the oversize material. A lack of fines to ensure proper compacting may pose minor processing problems. Similar material to that exposed in the road-cut was uncovered in test pits placed in the northern esker segments.

The esker segments occupy approximately 390 acres (158 ha). Cultural constraints reduce the area currently available to 330 acres (134 ha). Assuming an average thickness of 40 feet (12 m), available sand and gravel resources are estimated to total 33 million tons (30 million tonnes). The southernmost esker ridge is accessible via Windigo Lake road. The position of the northernmost esker ridges along the banks of the Pipestone River may restrict extractive development.

**SELECTED SAND AND GRAVEL RESOURCE AREA 4**

Selected Sand and Gravel Resource Area 4 consists of two esker segments and an associated ice-contact deposit. The deposits are situated within a bedrock controlled valley which extends from Zeemel Lake to Barrigar Lake in the north-central part of the project area.

The esker segments have been designated as Area 4a. They rise from 30 to over 100 feet (9 to over 30 m) above the surrounding terrain. Coarse granular material is common on the surfaces of these ridges. One pit (pit No. 2) has been developed in the northernmost esker ridge to supply material for the development of the winter road. The 10 foot (3 m) faces in this pit reveal variable material ranging from silty fine sand to pockets of coarse gravel with abundant oversize material. The gravel within the pockets may be suitable for crushing with selective extraction measures. The fine grained aggregate appears well suited for pit-run uses. Similar quality material is likely available in the undeveloped parts of Area 4a.

The esker ridges are flanked by an ice-contact deposit (Area 4b). In places, the Paseminon River has cut into the sides of this ice-contact deposit. These cuts reach heights of 5 to 50 feet (1.5 to 15 m) exposing material ranging from sand with minor gravel to sandy fine gravel. Samples

OP-SS-8 and OP-SS-9 were taken from these exposures and contained 36 and 14 percent gravel, respectively (Figure 6a). This material appears best suited for pit-run uses as gravel in the crushable size range is lacking. Coarse gravel may be available in close proximity to the esker ridges. Silt and clay was observed in localized areas within Area 4b and should be avoided during extraction.

Resource Area 4 totals 630 acres (255 ha), of which 550 acres (223 ha) are considered available for extraction. Assuming a deposit thickness of 40 and 30 feet (12 and 9 m) for Areas 4a and 4b, respectively, resources are estimated to be 44 million tons (40 million tonnes).

**SELECTED SAND AND GRAVEL RESOURCE AREA 5**

An esker ridge and four ice-contact deposits located south of Opapimiskan Lake are included in Selected Sand and Gravel Resource Area 5. The esker ridge (Area 5a) has local relief varying from 15 feet (5 m) in the south to over 60 feet (18 m) in the north. Pit no. 1 has been opened in the esker along the winter road. The 15 foot (5 m) faces in the pit expose sand with between 10 and 35 percent fine gravel. The gravel is generally too fine for crushing, but the material appears well suited for pit-run uses. Medium sand is the predominant material exposed in a shallow test pit excavated in the northern part of the deposit (OP-SS-5; Figure 5a). This sand may be suitable for use as Granular Base Course C.

Area's 5b and 5c are ice-contact deposits associated with the esker. Area 5b is a prominent mound with relief of over 100 feet (30 m). The three ice-contact deposits which form Area 5c exhibit more subdued relief in comparison to Area 5b and gradually decrease in thickness away from the esker ridge. Like the esker, Areas 5b and 5c consist predominantly of sandy aggregate. Clean medium to coarse

sand with minor fine gravel is exposed in several cuts along the winter road, which crosses these deposits. The most readily produced aggregate products from these deposits probably include Granular Base Course B and C, and fill.

The deposits included in Resource Area 5 total 200 acres (81 ha). Cultural constraints and previous extraction reduce the area currently available to 175 acres (71 ha). Assuming average thicknesses ranging from 10 to 40 feet (3 to 12 m) for the deposits, available resources of sand and gravel are estimated to be 9 million tons (8 million tonnes). The position of the northern part of Area 5a along the shore of Opapimiskan Lake may inhibit extractive development.

**SELECTED SAND AND GRAVEL RESOURCE AREA 6**

Selected Sand and Gravel Resource Area 6 consists of three esker segments and six associated ice-contact deposits. The Resource Area is located along the eastern boundary of the report area near Opapimiskan Lake. The esker ridges have been designated as Area 6a and vary in height between 15 and 50 feet (5 and 15 m). Wave cut terraces exist along the flanks of the southernmost ridge. Sediments exposed on the surface of Area 6a range from sand to coarse gravel. A sample (OP-SS-2) taken from a shallow test pit on the crest of the southernmost ridge consisted predomionantly of sand suitable for low specification use (Figure 4a). Higher specification aggregate may be available from areas containing greater amounts of gravel. A test pit was excavated in one such area in the central esker ridge. Sample OP-SS-1 taken from this test pit contained 50 percent gravel, 49 percent sand and 1 percent fines (Figure 4a). Sixty-two percent of the gravel was in the crushable size range.

Area 6b is a 100-foot (30 m) high ice-contact ridge located northeast of Zeemel Lake. Sediments uncovered in several test pits excavated in the ridge revealed material ranging from coarse sand to crushable gravel. The deposit appears to have significant potential for extraction of both pit-run and crusher-run aggregate products, but detailed subsurface testing is recommended to assess the continuity of the aggregate at depth.

Areas 6c and 6d are hummocky ice-contact features pitted by several kettle depressions. Medium sand is the dominant sediment exposed at the surface of these deposits, although gravel is exposed in localized areas. Sample OP-SS-3 was taken from a test pit excavated in one such gravel bearing area. It contained 37 percent gravel, 60 percent sand and 3 percent fines (Figure 4a). Possible uses of the material include Granular Base Course B and C, fill, hot-laid sand and concrete sand. Overall, Areas 6c and 6d are considered potential sources of pit-run aggregate and may contain localized areas suitable for extraction of higher specification products.

Resource Area 6 occupies 1180 acres (480 ha), of which 1070 acres (435 ha) are considered to be presently available for extraction. Based on average deposit thickness estimates ranging from 15 to 40 feet (5 to 12 m) for the deposits, available aggregate resources total approximately 50 million tons (45 million tonnes). The close proximity of parts of the Resource Area to Opapimiskan and Skinner Lakes may restrict pit development. The area is currently inaccessible via road.

## SELECTED SAND AND GRAVEL RESOURCE AREAS OF SECONDARY SIGNIFICANCE

Several deposits are recommended for resource protection at the secondary level of significance. Although these deposits tend to be more limited in respect to the amount of available resources and the quality of the material than the resources selected at the primary level, they add significantly to the resource base of the report area.

Two deltaic deposits, three eskers and nine ice-contact deposits have been selected at the secondary level in the southern part of the report area. The largest of these are the two deltaic deposits situated along the Pipestone River north of the Agutua Moraine. These features are relatively flat to gently rolling and consist predominantly of medium sand. Possible uses of the sand include granular sub-base and fill. The three esker ridges are potential gravel sources. Only limited amounts of material may be available for extraction from these ridges, however, because of their small areal extent and the presence of lakes adjacent to two of these deposits. Most of the ice-contact deposits are associated with esker systems which traverse the area. These hummocky features often contain deep kettle depressions. They likely consist of finer material than the esker ridges, although localized areas may contain significant quantities of coarse aggregate. Sand and gravelly sand, suitable for low specification aggregate use, were the dominant materials observed in exposures of the ice-contact deposits which flank Resource Area 3. The isolated ice-contact deposit in which pit no. 5 has been opened is not associated with an esker. Five to eight feet (1.5 to 2.5 m) of fine gravel with a coarse sand matrix is exposed in this pit. This material is well suited for pit-run uses and aggregate from this source has been utilized for construction of the winter road.

Along the southeastern shore of Barrigar Lake two ice-contact ridges have been selected at the secondary level. These ridges rise up to 60 feet (18 m) above the lake level and sandy fine gravel to bouldery coarse gravel is exposed on their surfaces. These deposits are situated in the aggregate poor central part of the report area and detailed subsurface investigation is warranted to assess the quality of the material at depth.

Fourteen deposits have been selected at the secondary level in the northern part of the report area. These include two esker segments and three ice-contact deposits situated between Resource Area 4 and Barrigar Lake. These features were deposited in a similar geological environment as Resource Area 4 along a bedrock controlled valley extending from Zeemel Lake to Barrigar Lake. A 15 foot (5 m) section in the core of the southernmost esker ridge revealed coarse gravel with abundant oversize material. Finer sediments consisting of sand and fine gravel are exposed along the flanks of the esker. Little subsurface information is available for the three ice-contact deposits, but as they are part of the same glaciofluvial system responsible for deposition of Resource Area 4, they likely consist of similar materials. The depth to bedrock may be variable in these deposits and detailed subsurface testing is recommended prior to development.

An ice-contact deposit is located between Libert Lake and Zeemel Lake along the winter road. Pit no. 3 has been developed in this relatively flat feature. Five to six feet (1.5 to 2 m) of medium to coarse sand with occasional boulders is exposed in the pit. The material appears best suited for granular sub-base and fill applications. Water was observed on the pit floor indicating a potentially high water table.

Along the southern shore of Zeemel Lake two eskers and an associated ice-contact deposit are located. The esker segments have local relief varying from 10 to 75 feet (3 to 23 m) and the ice-contact feature rises over 100 feet (30 m) above the surrounding terrain. A 3 foot (1 m) deep test pit in the easternmost esker segment uncovered fine to coarse gravel in a coarse sand matrix. The material appeared to contain suficient quantities of coarse gravel for crushing purposes. Finer material is likely available from the ice-contact ridge. The position of these deposits in close proximity to Zeemel Lake may inhibit future extractive development.

Two ice contact deposits located north of Opapimiskan Lake are part of the same glaciofluvial system that formed Resource Area 5. The southernmost ridge consists predominantly of medium to coarse sand suitable for low specification aggregate use. Even though the northernmost ice-contact deposit is of small size as portrayed on the maps, it extends a considerable distance northeastward outside the map area. Significant amounts of sand and gravel may be available from the overall deposit.

The final areas selected at the secondary level include two esker segments and an ice-contact deposit along the western border of the northern part of the report area. No subsurface information is presently available for these features and deposit boundaries have been delineated by airphoto interpretation. However, based on data for other esker and ice-contact deposits in the report area, significant resources of quality aggregate may be available in these deposits.

## SAND AND GRAVEL RESOURCES OF TERTIARY SIGNIFICANCE

The remaining resources in the area are classified at the tertiary level of significance. They represent deposits in which the material is of low or undetermined quality, or in which only limited resources are available. Many of these tertiary deposits consist of sand deposited in glaciolacustrine and eolian environments. This material is best suited for low grade aggregate uses such as granular borrow. These deposits may be valuable when short haul distances are of more importance than material quality.

Several esker and ice-contact deposits along the shore of Opapimiskan Lake, northeast of Resource Area 5, have also been designated as tertiary resources. They consist of sandy gravel which appears well suited for pit-run uses. However, the close proximity of these features to the lake and the restricted depth of the more northerly deposits may inhibit extractive depvelopment.

Localized areas within the ice-contact deposit situated between Resource Areas 6b and 6c may be suitable for extractive development. The deposit exhibits a very hummocky topography. A number of these hummocks appear to have good aggregate potential, but others may be composed largely of till.

**SUMMARY**

The sand and gravel deposits of the report area are the product of glacial activity which occurred during the Late Wisconsinan Substage of the Pleistecone Epoch. Thirty-one deposits containing significant amounts of sand and gravel have been selected at the primary level of significance. These deposits have been grouped into six Primary Resource Areas. Several deposits have also been selected at the secondary level and these deposits add considerably to the report area's resource base.

The sand and gravel in the Opapimiskan Lake Area is generally of high quality. Undesirable materials appear to be insignificant with only minor occurrences of chert and highly weathered clasts. The aggregate contains no significant content of fines; in fact the material is so clean in some localities that fines may have to be added to ensure proper compaction when the material is used for road construction. The available aggregate should meet the specifications for most road-building and construction applications, including crushable aggregate for use in structural concrete. A major concern in the area is that resources are scarce in the central part of the study area. Aggregate supplies are considered adequate in vicinity of Opapimiskan Lake and Windigo Lake road.

Enquiries regarding the aggregate inventory of the Opapimiskan Lake Area should be directed to the Aggregate Assessment Office, Ontario Geological Survey, Ontario Ministry of Northern Development and Mines, Room M1B-45, Macdonald Block, Queen's Park, Toronto, Ontario, M7A 1W3 [Tel. (416) 965-1663], or to the Sioux Lookout Resident Geologist's Office, Ontario Ministry of Northern Development and Mines, P.O. Box 309, Court House, Sioux Lookout, Ontario, P0V 2T0 [Tel.(807) 737-1291].

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, Opapimiskan Lake Area

| 1<br>CLASS NO. | 2<br>DEPOSIT TYPE<br>(see Appendix C) | 3<br>AREAL EXTENT<br>Acres<br>(Hectares) | 4<br>ORIGINAL TONNAGE<br>Millions of<br>Tons<br>(Tonnes) |
|---|---|---|---|
| 1 | G-E | 660<br>(265) | 66<br>(60) |
| | G-EM | 7600<br>(3100) | 760<br>(690) |
| | G-IC | 250<br>(101) | 21<br>(19) |
| | G-LD-EM | 14,300<br>(5800) | 1430<br>(1300) |
| | S-E | 175<br>(71) | 14<br>(13) |
| | S-IC | 3500<br>(1420) | 225<br>(204) |
| | S-LD-EM | 400<br>(162) | 25<br>(23) |
| | S-LD | 4250<br>(1720) | 265<br>(240) |
| | S-WD | 27<br>(11) | 2<br>(2) |
| 2 | G-E | 160<br>(65) | 6<br>(5) |
| | S-E | 28<br>(11) | 1<br>(1) |
| | S-IC | 1530<br>(620) | 56<br>(51) |
| | S-LD-EM | 390<br>(158) | 15<br>(14) |
| | S-LP-LD | 345<br>(140) | 13<br>(12) |
| 3 | G-IC | 125<br>(51) | 2<br>(2) |
| | G-LB | 3<br>(1) | <1<br>(<1) |
| | S-E | 115<br>(47) | 2<br>(2) |

N.B. Minor variations in all tables are caused by rounding of data.

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, Opapimiskan Lake Area

| 1<br>CLASS NO. | 2<br>DEPOSIT TYPE<br>(see Appendix C) | 3<br>AREAL EXTENT<br>Acres<br>(Hectares) | 4<br>ORIGINAL TONNAGE<br>Millions of<br>Tons<br>(Tonnes) |
|---|---|---|---|
| 3 | S-IC | 1230<br>(500) | 25<br>(23) |
| | S-IC-LP | 145<br>(59) | 2<br>(2) |
| | S-LP | 1020<br>(415) | 15<br>(14) |
| | S-LP-LD | 530<br>(214) | 11<br>(10) |
| | S-LP-WD | 150<br>(61) | 3<br>(3) |
| | S-WD | 2700<br>(1090) | 61<br>(55) |
| 4 | G-IC | 265<br>(107) | 3<br>(3) |
| | S-IC | 32<br>(13) | <1<br>(<1) |
| TOTAL FOR REPORT AREA | | 40,000<br>(16 200) | 3000<br>(2700) |

TABLE 2 - SAND AND GRAVEL PITS, OPAPIMISKAN LAKE AREA

| 1 NO. | 2 FACE HEIGHT Feet (Metres) | 3 % GRAVEL | 4 REMARKS |
|---|---|---|---|
| 1 | 15 (5) | 10-35 | material ranges from clean medium sand to sandy fine gravel |
| 2 | 10 (3) | 10-50 variable | material ranges from silty fine sand to pockets of coarse gravel |
| 3 | 5-6 (1.5-2) | - sand | medium to coarse sand with occasional boulders, water observed on pit floor |
| 4 | 8 (2) | - | 4 feet (1.2m) of gravelly sand and sandy gravel over stony, very silty, fine sand till; water on pit floor |
| 5 | 5-8 (1.5-2) | 35 | fine gravel with coarse sand matrix |
| 6 | 4 (1.2) | 40-60 | predominantly fine to medium gravel |
| 7 | 3-4 | 30 | medium to coarse sand with fine gravel |
| 8 | 20-30 (6-9) | - | slumped faces with abundant medium to coarse gravel |
| 9 | 3-5 (1-1.5) | 5 | medium to coarse sand with minor fine gravel |
| 10 | 5-8 (1.5-2) | 30-50 | gravel concentrated in upper 2 feet (0.6 m) under which clean medium to coarse sand with minor fine gravel is exposed |
| 11 | 2-3 (0.6-1) | - sand | medium sand |
| 12 | 5-8 (1.5-2) | - mainly sand | medium to coarse sand with minor fine gravel, thin silt seam observed |
| 13 | 5-8 (1.5-2) | - sand | clean medium sand |
| 14 | 3-4 (1-1.2) | - sand | clean medium sand |
| 15 | 10-12 (3-4) | 40-60 | sandy gravel with medium to coarse sand matrix; higher gravel contents in the eastern faces of the pit |
| 16 | - | - | pit faces have been graded; fine to medium gravel on pit floor |

TABLE 3 | SELECTED SAND AND GRAVEL RESOURCE AREAS, Opapimiskan Lake Area

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| Deposit No. | AREA Acres (Hectares) | CULTURAL SETBACKS Acres (Hectares) | EXTRACTED AREA Acres (Hectares) | AVAILABLE AREA Acres (Hectares) | ESTIMATED DEPOSIT THICKNESS Feet (Metres) | AVAILABLE AGGREGATE Millions of Tons (Tonnes) |
| 1a | 14,300 (5800) | 390 (158) | 10 (4) | 13,900 (5600) | 40 (12) | 1390 (1260) |
| 1b | 7600 (3100) | 190 (77) | 10 (4) | 7400 (3000) | 40 (12) | 740 (670) |
| | 21,900 (8900) | 580 (235) | 20 (8) | 21,300 (8600) | | 2130 (1930) |
| 2 | 110 (45) | 10 (4) | 0 (0) | 100 (40) | 30 (9) | 8 (7) |
| 3 | 390 (158) | 60 (24) | 0 (0) | 330 (134) | 40 (12) | 33 (30) |
| 4a | 160 (65) | 39 (16) | 1 (0.4) | 120 (49) | 40 (12) | 12 (11) |
| 4b | 470 (190) | 40 (16) | 0 (0) | 430 (174) | 30 (9) | 32 (29) |
| | 630 (255) | 79 (32) | 1 (0.4) | 550 (223) | | 44 (40) |
| 5a | 70 (28) | 18 (7) | 2 (0.8) | 50 (20) | 25 (8) | 3 (3) |
| 5b | 35 (14) | 0 (0) | 0 (0) | 35 (14) | 40 (12) | 4 (4) |
| 5c | 95 (38) | 5 (2) | 0 (0) | 90 (36) | 10 (3) | 2 (2) |
| | 200 (81) | 23 (9) | 2 (0.8) | 175 (71) | | 9 (8) |
| 6a | 105 (42) | 20 (8) | 0 (0) | 85 (34) | 35 (11) | 7 (6) |
| 6b | 90 (36) | 0 (0) | 0 (0) | 90 (36) | 40 (12) | 9 (8) |
| 6c | 920 (370) | 70 (28) | 0 (0) | 850 (345) | 15 (5) | 32 (29) |
| 6d | 65 (26) | 20 (8) | 0 (0) | 45 (18) | 21 (6) | 2 (2) |
| | 1180 (480) | 110 (45) | 0 (0) | 1070 (435) | | 50 (45) |
| Total for Report Area | 24,400 (9 900) | 860 (350) | 23 (9) | 23,500 (9500) | | 2270 (2060) |

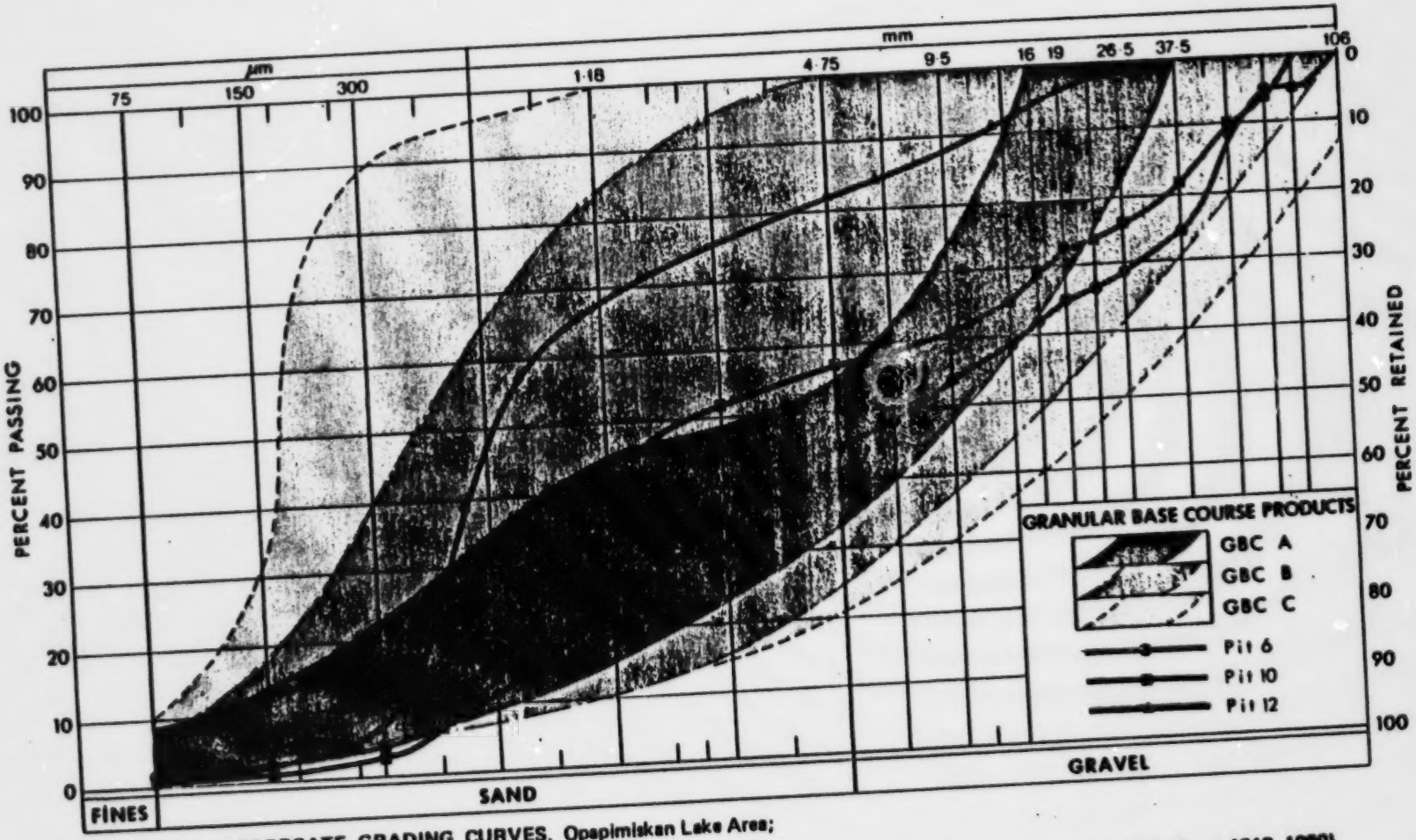


**FIGURE 2a: AGGREGATE GRADING CURVES, Opapimiskan Lake Area;**

**Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).**

**NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.**

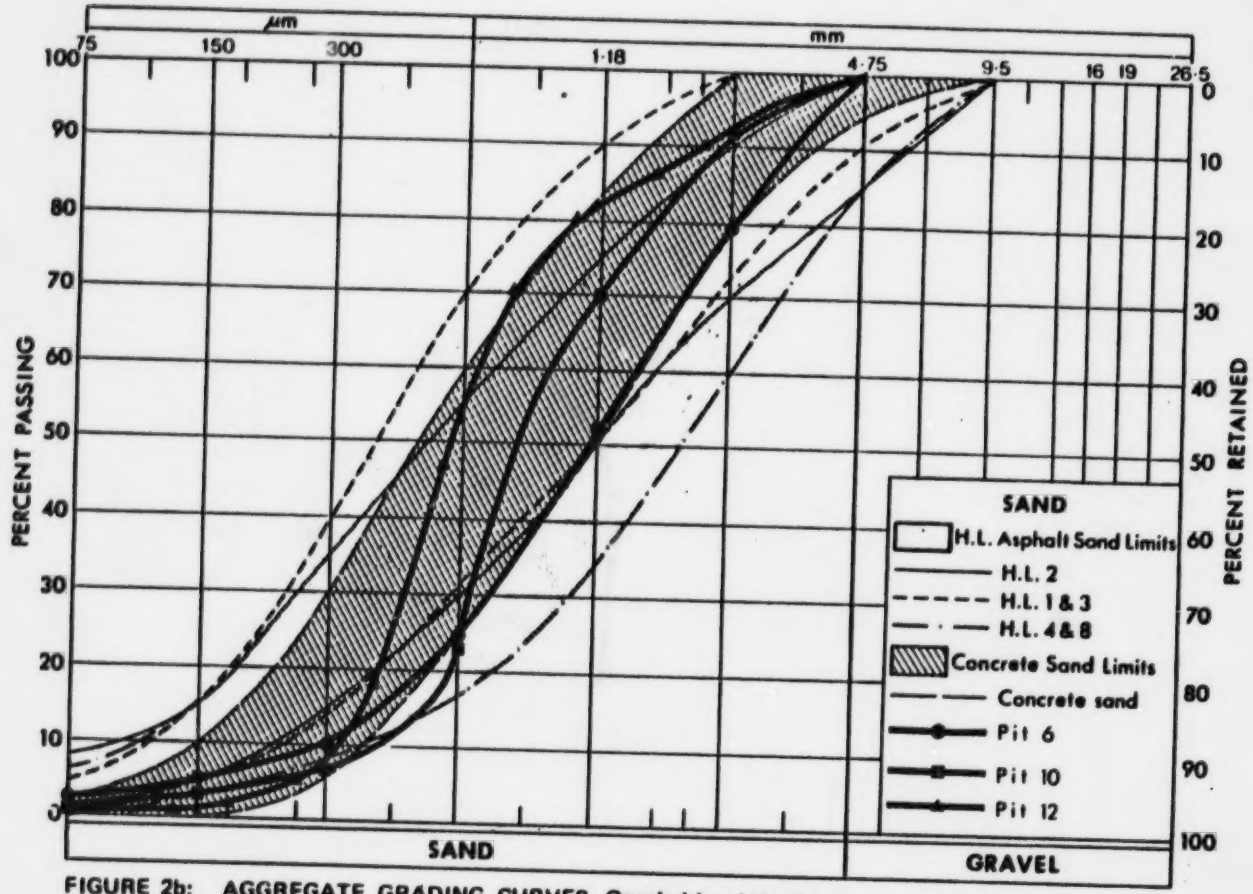


FIGURE 2b: AGGREGATE GRADING CURVES, Opapimiskan Lake Area;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

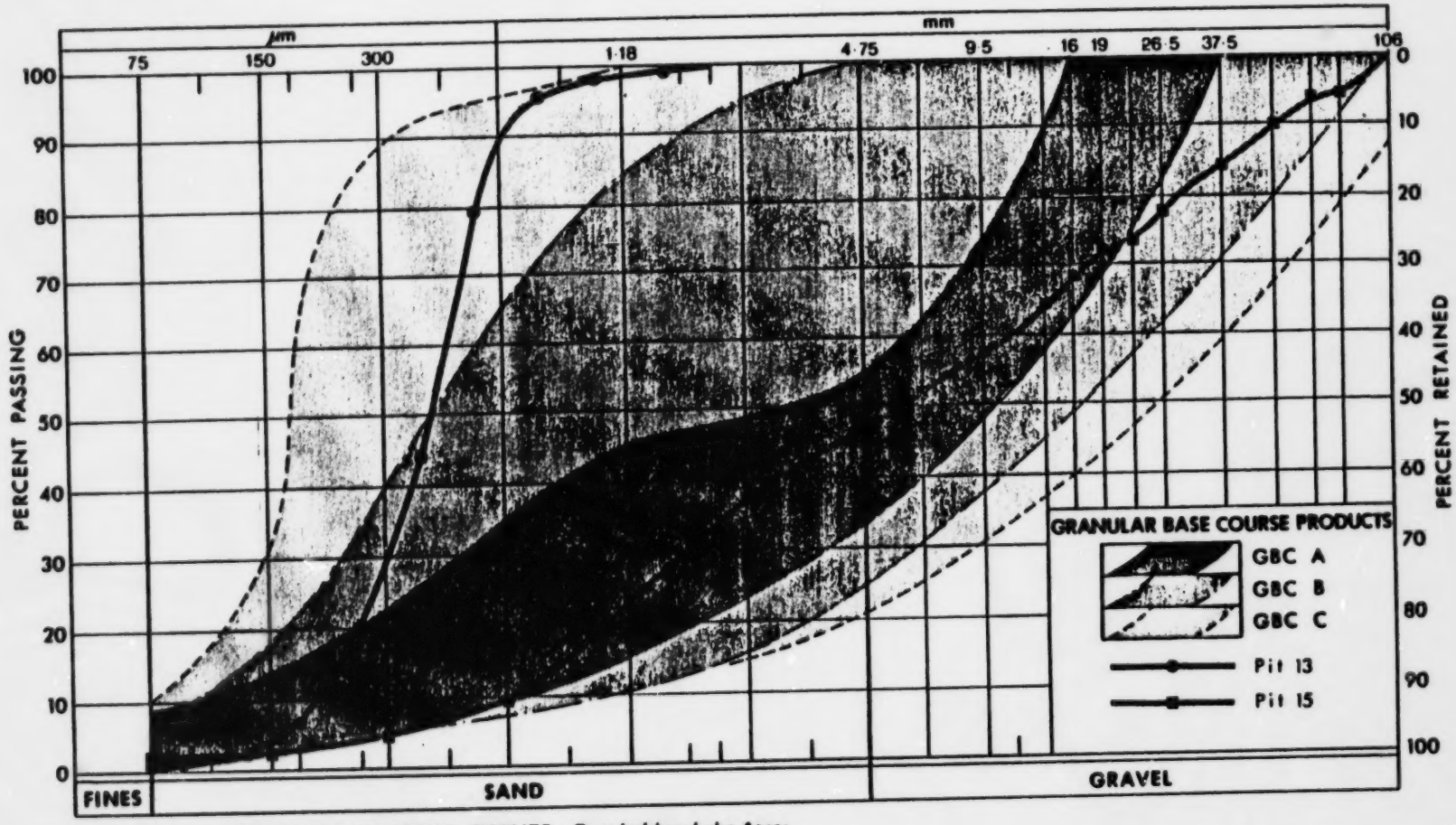


FIGURE 3a: AGGREGATE GRADING CURVES, Opapimiskan Lake Area;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

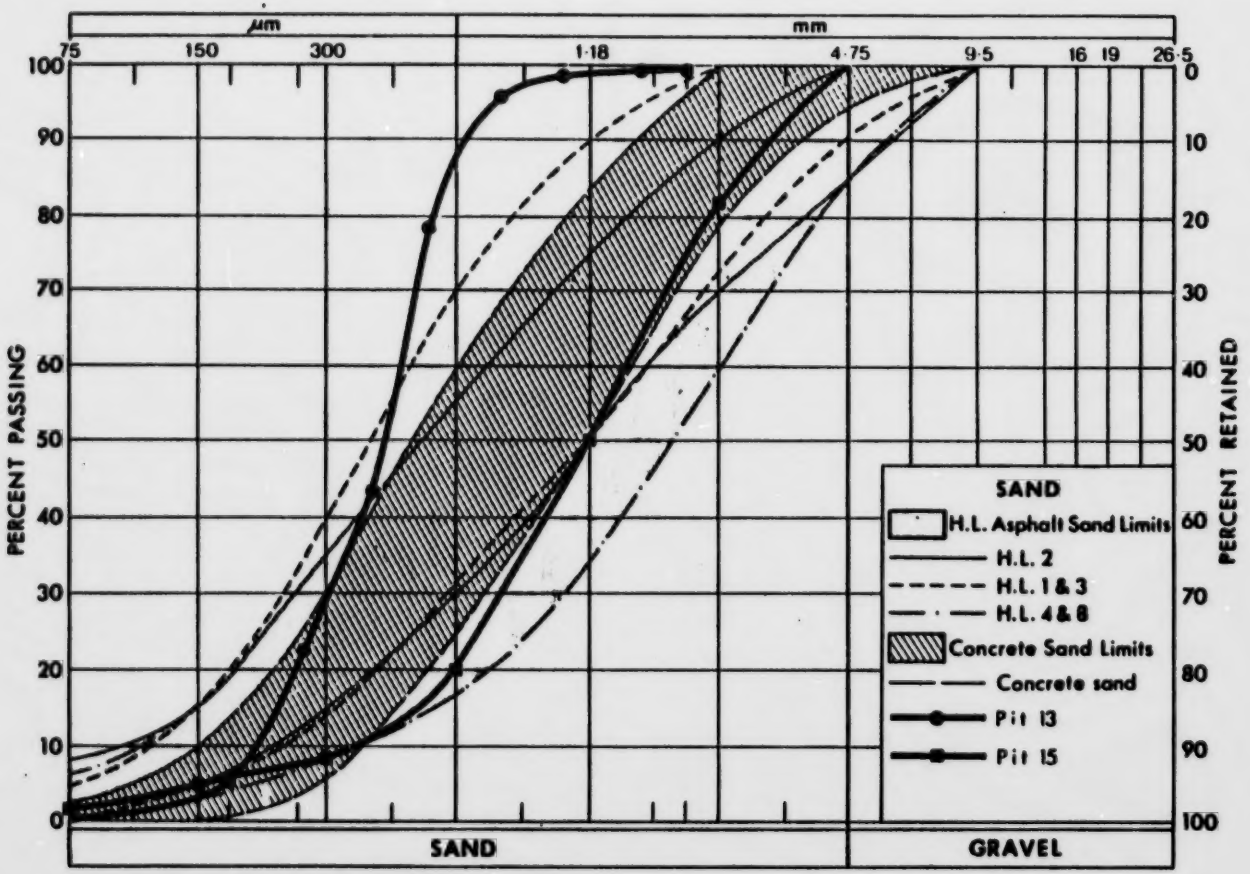


FIGURE 3b: AGGREGATE GRADING CURVES, Opapimiskan Lake Area;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

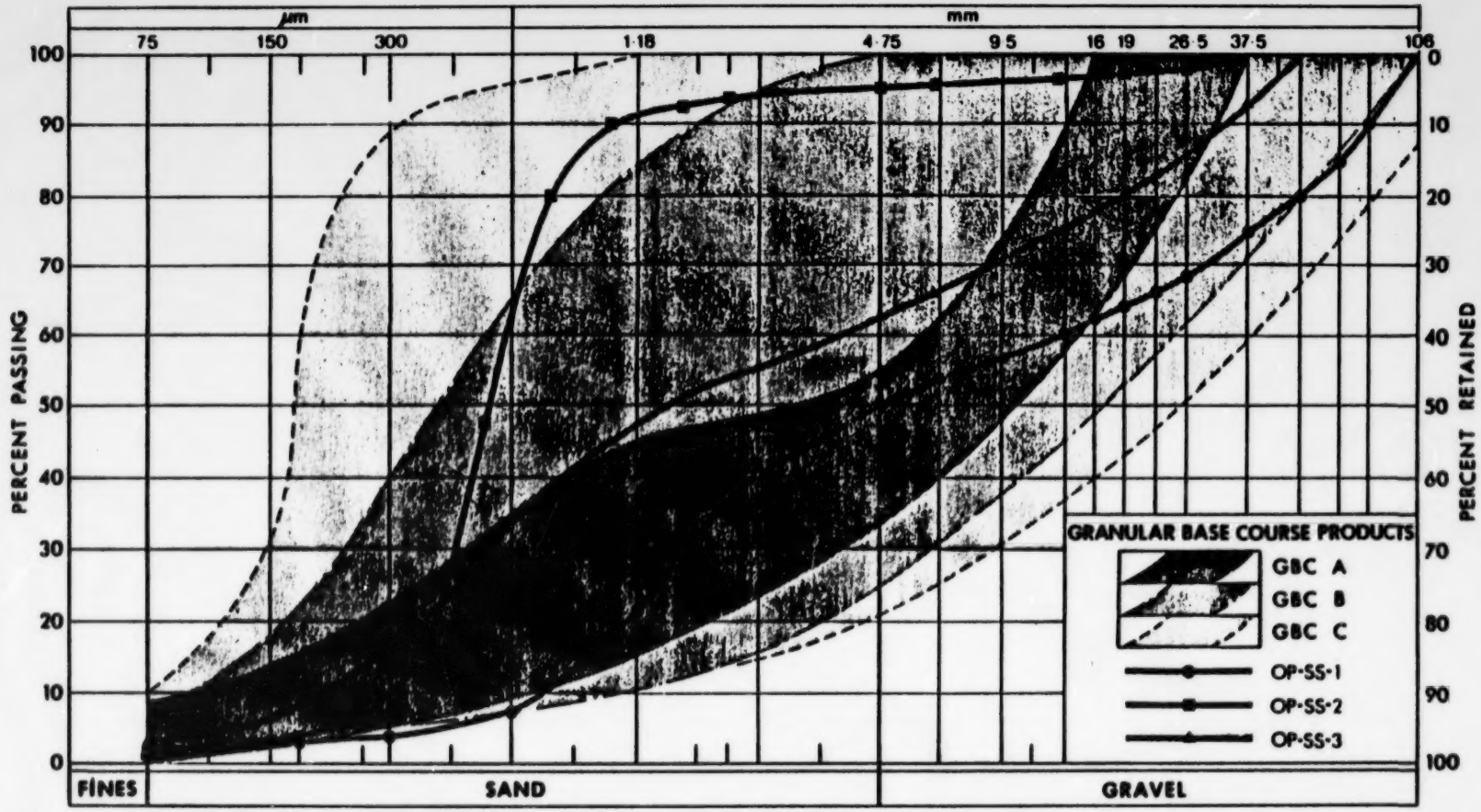


FIGURE 4a: AGGREGATE GRADING CURVES, Opapimiskan Lake Area;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

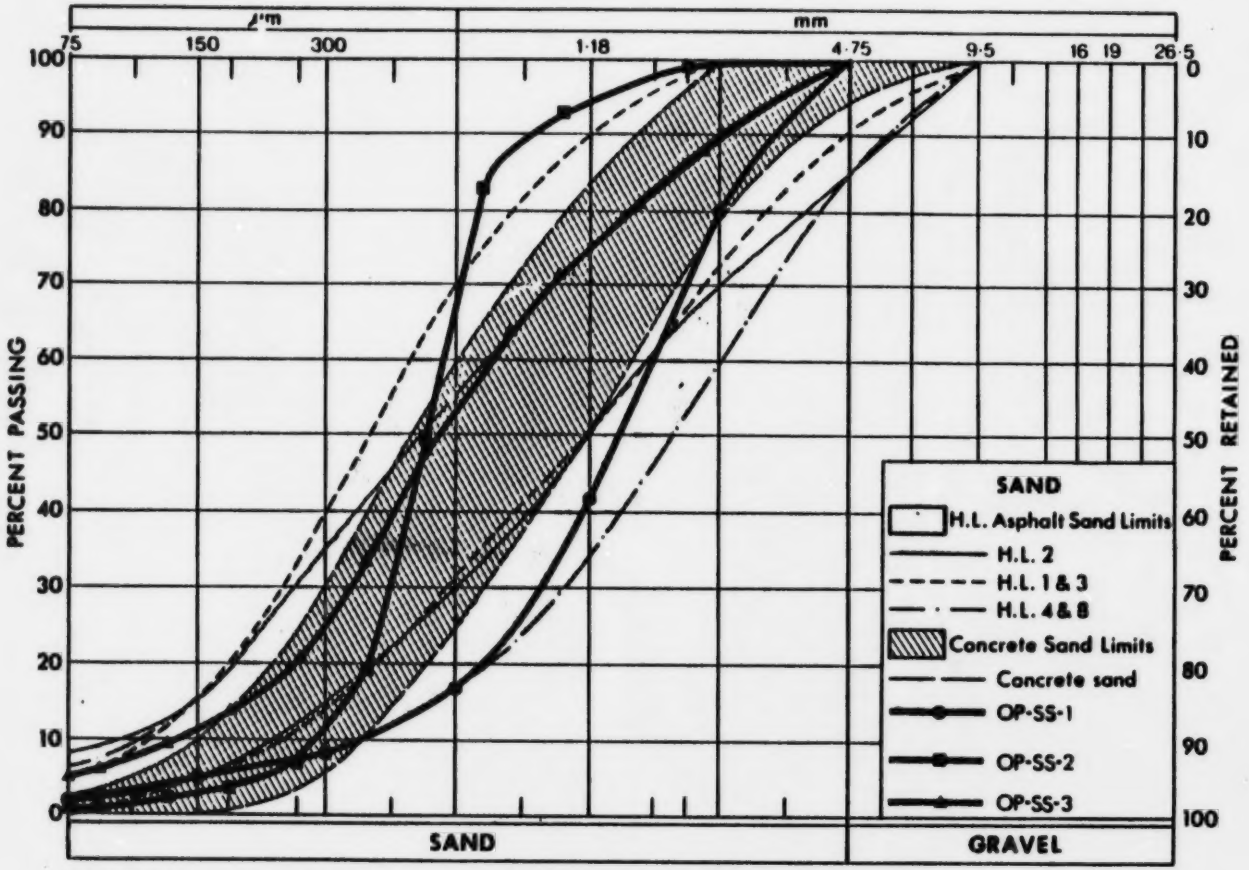


FIGURE 4b: AGGREGATE GRADING CURVES, Opapimiskan Lake Area;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

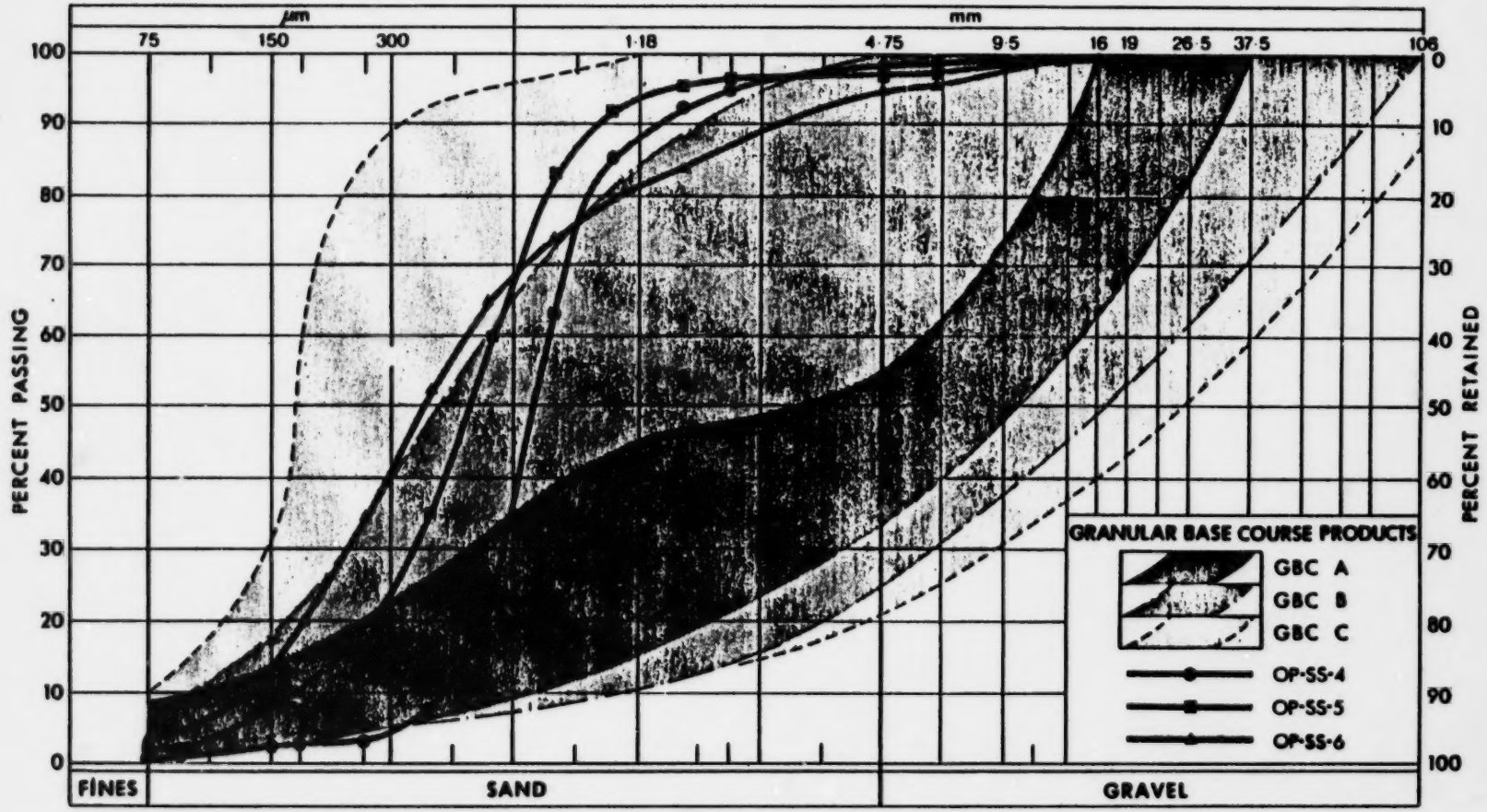


FIGURE 5a: AGGREGATE GRADING CURVES, Opapimiskan Lake Area;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

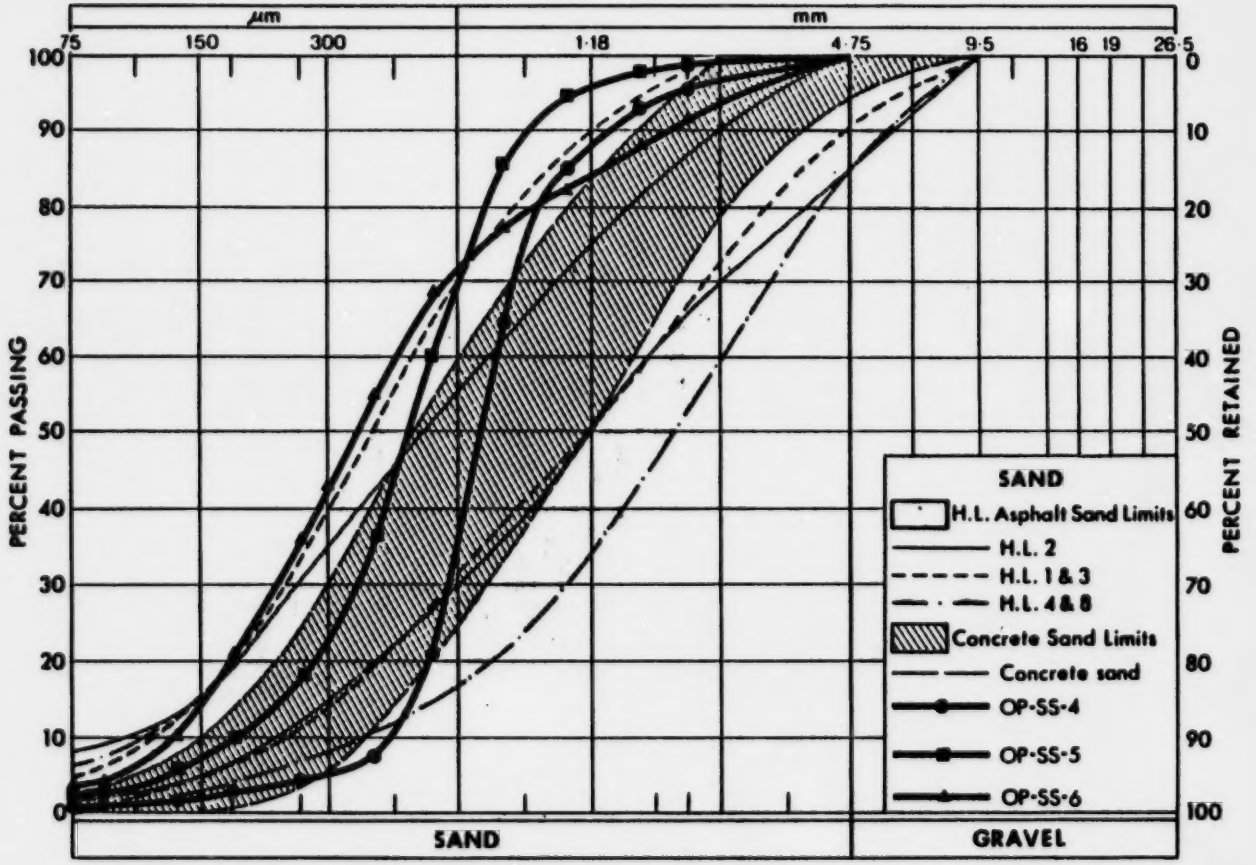


FIGURE 5b: AGGREGATE GRADING CURVES, Opapimiskan Lake Area;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

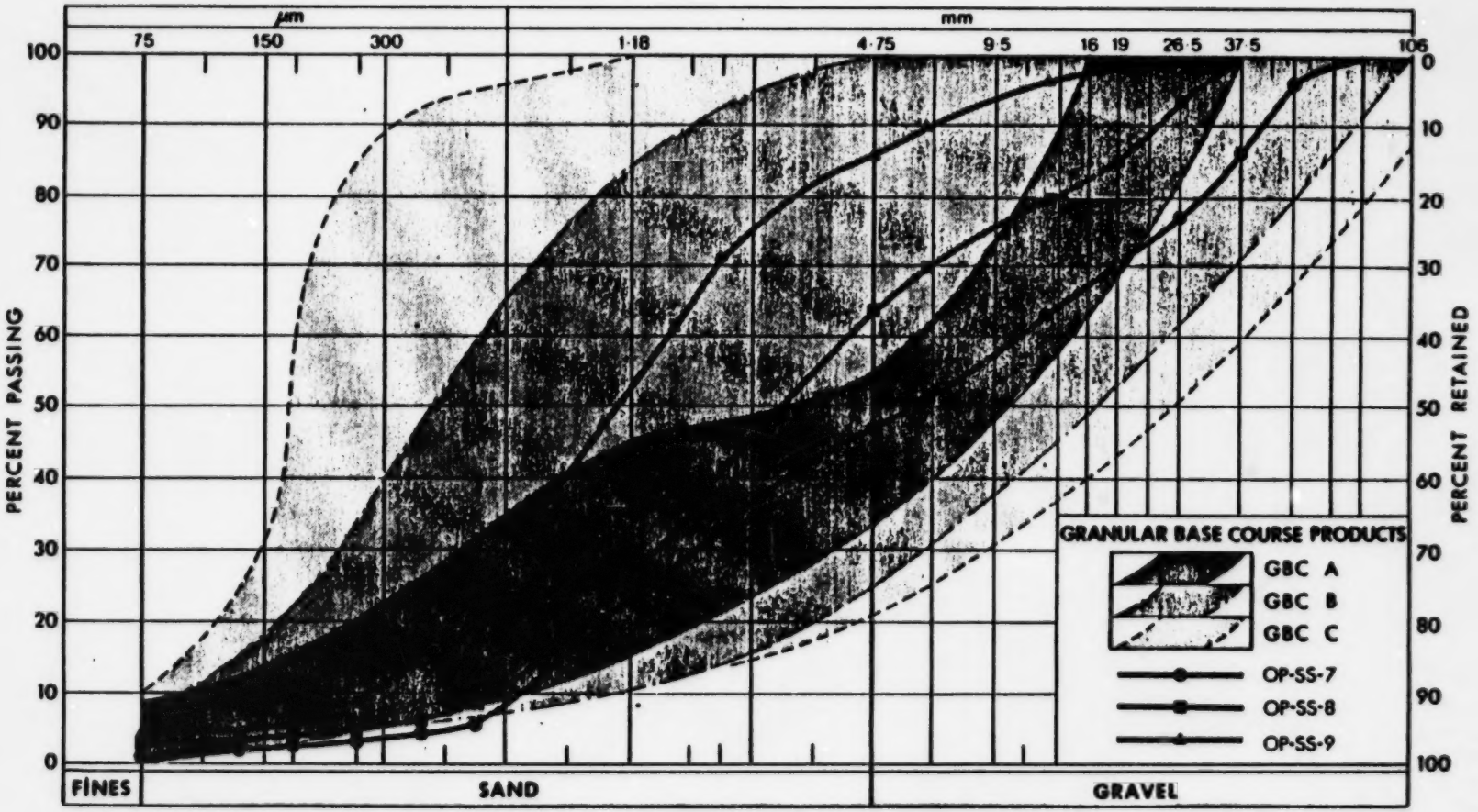


FIGURE 6a: AGGREGATE GRADING CURVES, Opapimiskan Lake Area;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

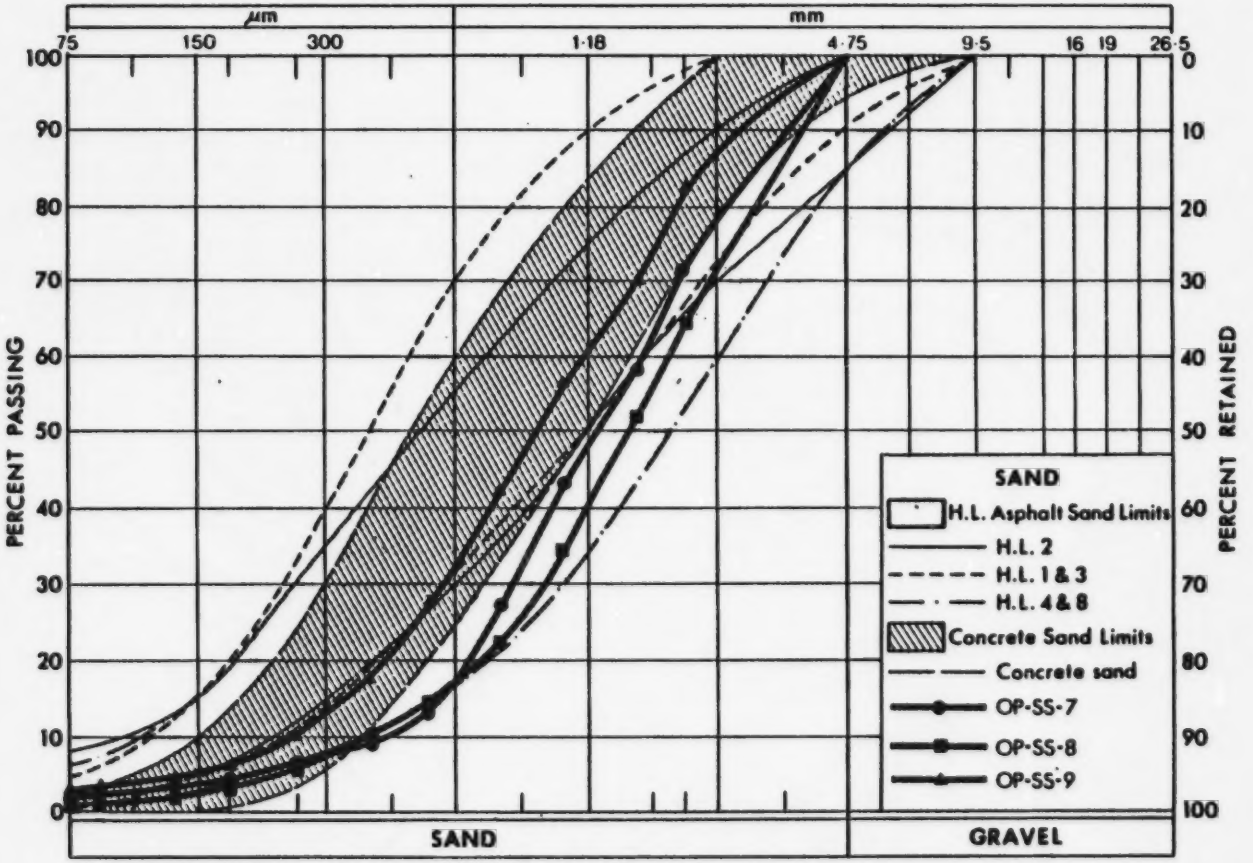


FIGURE 6b: AGGREGATE GRADING CURVES, Opapimiskan Lake Area;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

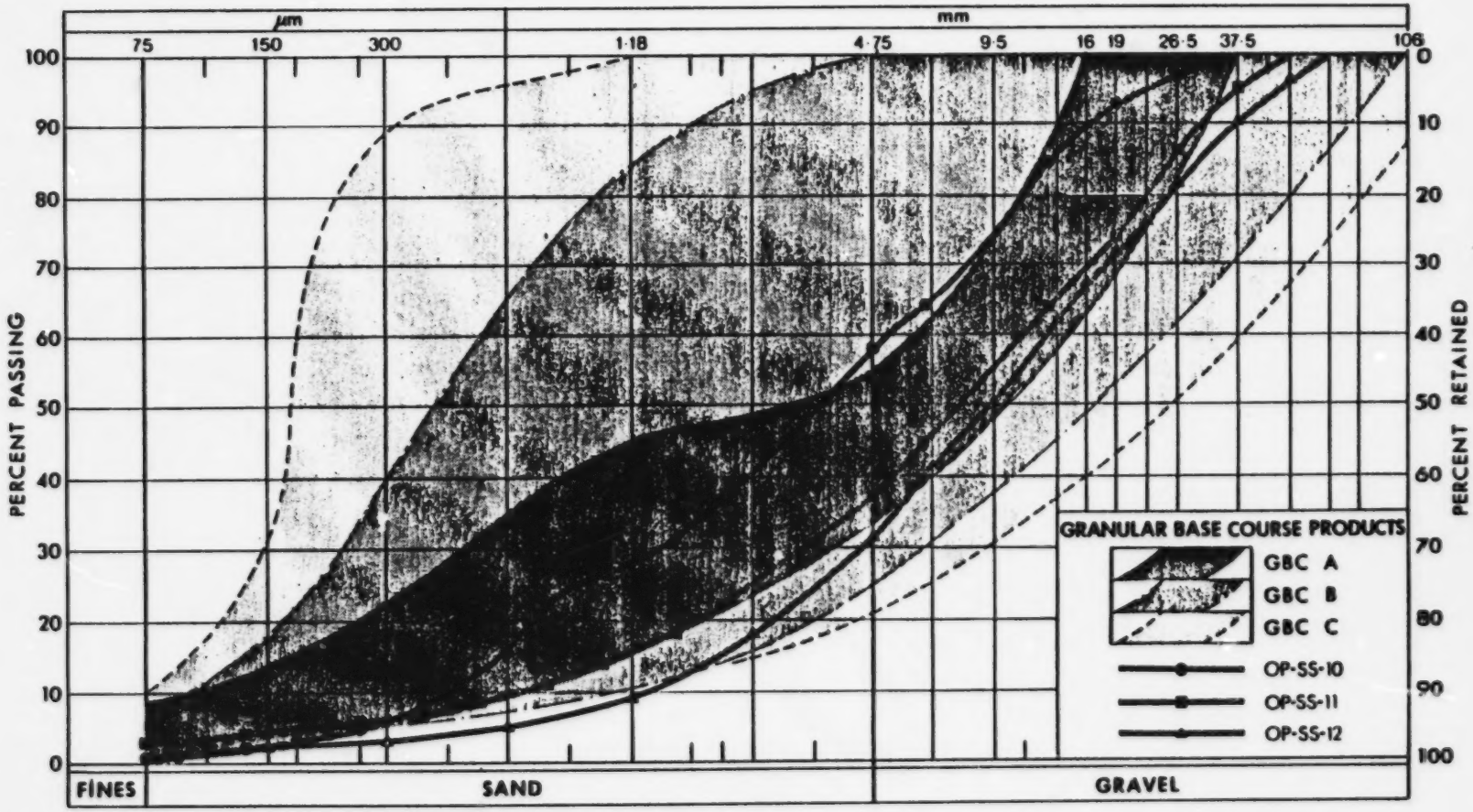


FIGURE 7a: AGGREGATE GRADING CURVES, Opapimiskan Lake Area;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

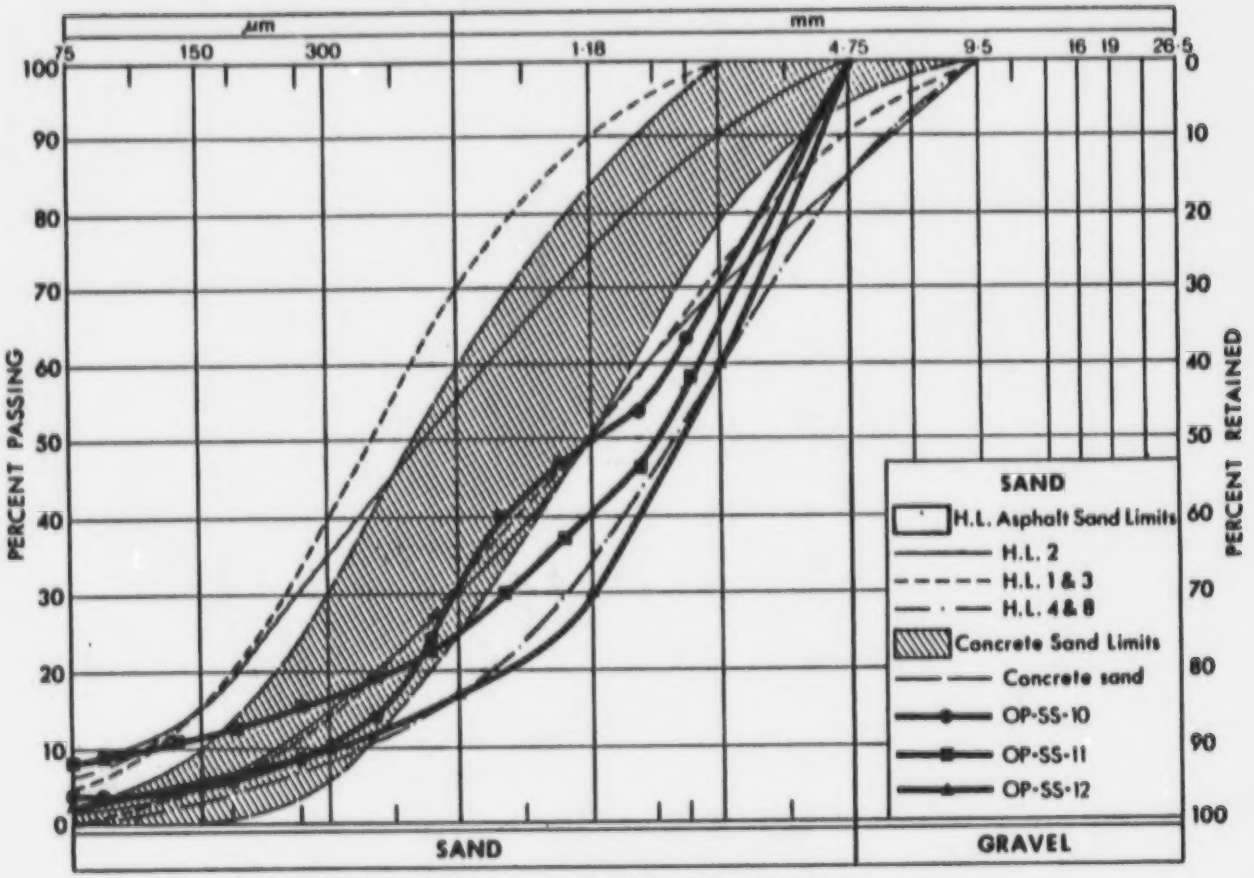


FIGURE 7b: · AGGREGATE GRADING CURVES, Opapimiskan Lake Area;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

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## APPENDIX A - PURPOSE, METHODOLOGY AND DATA PRESENTATION OF THE AGGREGATE RESOURCES INVENTORY*

### INTRODUCTION

Mineral aggregates, which include bedrock-derived crushed stone as well as naturally formed sand and gravel, constitute the major raw material in Ontario's road-building and construction industries. Very large amounts of these materials are used each year throughout the Province. For example, in 1982, the total tonnage of mineral aggregate extracted was 101 million tons (92 million tonnes), greater than that of any other metallic or nonmetallic commodity mined in the Province (Ontario Ministry of Natural Resources 1983).

Although mineral aggregate deposits are plentiful in Ontario, they are fixed-location, nonrenewable resources which can be exploited only in those areas where the deposits occur. Mineral aggregates are characterized by their high bulk and low unit value so that the economic value of a deposit is a function of its proximity to a market area, as well as its quality and size. The potential for extractive development is usually greatest where land use competition is extreme. For these reasons, the availability of adequate resources for future development is now being threatened in some areas.

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***This Appendix is made up of the standard Introduction and Part I and II from the Aggregate Resources Inventory Paper (ARIP) series (for example, see ARIP 89, Aggregate Resources Inventory of the Central Part of the City of Timmins). The text has been modified to correspond to the data presented in this Open File Report. The methodology and data presentation used in this OFR are identical to those used in the ARIP Series.**

Comprehensive planning and resource management stratagies are required to make the best use of available resources. Such strategies must be based on a sound knowledge of the total mineral aggregate resource base at both local and regional levels. The purpose of the Aggregate Resources Inventory is to provide the basic geological information required to include potential mineral aggregate resource areas in planning strategies. The reports should form the basis for discussion on those areas best suited for possible extraction. The aim is to assist decision-makers in protecting the public well-being by ensuring that adequate resources of mineral aggregate remain available for future use.

**This report is a technical background document, based for the most part on geological information and interpretation. It has been designed as a component of the total planning process and should be used in conjunction with other planning considerations, to ensure the best use of the resources.**

The report includes an assessment of all the sand and gravel resources in the study area. The most recent information available has been used to prepare the report. As new information becomes available, revisions may be necessary.

# PART I - INVENTORY METHODS

## FIELD AND OFFICE METHODS

The methods used to prepare the report involve the interpretation of published geological data such as bedrock and surficial geology maps and reports (see References), as well as field examination of potential resource areas. Field methods include the examination of natural and man-made exposures of granular material. Observations made at sand and gravel pits include estimates of the total face height and the proportion of gravel- and sand-sized fragments in the deposit. Observations are also made of the shape and lithology of the particles. These characteristics are important in estimating the quality and quantity of the aggregate. In areas of limited exposure, test pitting, soil probing and hand-augering techniques are used to assess subsurface materials. Airphotos are used to determine the continuity of deposits.

Deposits with potential for extractive development are studied in greater detail. Representative sections in these deposits are sampled from existing pit faces, test pits, and exposures along rivers and roads. The samples are analyzed for grain size distribution, and on selected samples Los Angeles abrasion, absorption and Magnesium Sulphate soundness tests, along with petrographic analyses, are performed.

Topographic maps of the National Topographic System, at a scale of 1:50 000, are used as a compilation base for the field and office data. The information is then transferred to a base map, also at a scale of 1:50 000, prepared by the Cartography Section of the Lands and Waters Group, Ontario Ministry of Natural Resources, for presentation in the report.

## RESOURCE TONNAGE CALCULATION TECHNIQUES

### Sand and Gravel Resources

Once the interpretative boundaries of the aggregate units have been drawn, quantitative estimates of the possible resources available can be made. Generally, the volume of a deposit can be calculated if its areal extent and average thickness are known or can be estimated. The computation methods used are as follows: First, the area of the deposit, as outlined on the final base map, is calculated in acres. The thickness values used are an approximation of the deposit thickness, based on the face heights of pits developed in the deposit or on topographic relief. Original tonnage values can then be calculated by multiplying the volume of the deposit by 2500 (the density factor). This factor is approximately the number of tons in a one-foot (0.3-m) thick layer of sand and gravel, one acre (0.4 ha) in extent, assuming an average density of 110 pounds per cubic foot (1766 kg per cubic metre).

Tonnage = Area x Thickness x Density Factor

Tonnage calculated in this manner must be considered only as an estimate. Furthermore, such tonnages represent amounts that existed prior to any extraction of material (i.e. original tonnage) (Table 1, Column 4).

The Selected Sand and Gravel Resource Areas in Table 3 are calculated in the following way. Two successive subtractions are made from the total area. Column 3 accounts for the number of acres unavailable due to the presence of permanent cultural features and their associated setback requirements. Column 4 accounts for those areas that have previously been extracted. The remaining figure is the area of the deposit currently available for extraction (Column 5). The available area is then

multiplied by the estimated deposit thickness and the density factor (Column 5 x Column 6 x 2500) to give an estimate of the sand and gravel tonnage presently available for extractive development and/or resource protection.

Reserve estimates are calculated for deposits of primary significance. Reserve estimates for deposits of secondary and teritary significance are not calculated in Table 3, however, the aggregate potential of these deposits is discussed in the report.

## UNITS AND DEFINITIONS

Although most of the measurements and other primary data available for resource tonnage calculations are given in Imperial units, Metric units have also been given in the text and on the tables which accompany the report. The Metric equivalent of the data is shown in brackets after or directly below the corresponding Imperial figures. Data are generally rounded off in accordance with the Ontario Metric Practice Guide (Metric Committee 1975).

The tonnage estimates made for sand and gravel are termed possible resources in accordance with terminology of the Ontario Resources Classification Scheme (Robertson 1975, p.7) and with the Association of Professional Engineers of Ontario (1976).

## PART II - DATA PRESENTATION AND INTERPRETATION

There are two maps, each portraying a different aspect of the aggregate resources in the report area. Map 1, "Distribution of Sand and Gravel Deposits", gives a comprehensive inventory of the sand and gravel resources in the report area. Map 2, "Selected Sand and Gravel Resource Areas", shows those deposits which are considered to represent the largest and/or highest quality resources in the area.

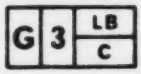
### MAP 1: DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

Map 1 is derived from existing surficial geology maps, field investigation and from airphoto interpretation. The map represents a comprehensive inventory of sand and gravel deposits within the project area and serves as a base for the calculation of total sand and gravel resources. The map also represents a summary of all available information related to the quality of aggregate in the mapped deposits. Much of this information is contained in two symbols which appear on the map. The Deposit Symbol appears for each mapped deposit and summarizes important genetic and textural data. The Texture Symbol is a circular proportional diagram which displays the grain size distribution of the aggregate in areas where bulk samples were taken.

#### Deposit Symbol

The Deposit Symbol is similar to those used in soil mapping and land classification systems commonly in use in North America. The components of the symbol indicate the gravel content, thickness of material, origin (type), and quality limitations for every deposit shown on Map 1. These components are illustrated by the following example:

Gravel Content Geological Type




Thickness Class Quality

This symbol identifies a lacustrine beach deposit 5 to 10 feet (1.5 to 3 m) thick containing more than 35 percent unprocessed gravel. Excess fines may limit uses of the aggregate in the deposit.

The "gravel content" and "thickness class" are basic criteria for distinguishing different deposits. The "gravel content" symbol is an upper case "S" or "G". The "S' indicates that the deposit is generally "sandy" and that gravel-sized aggregate makes up less than 35 percent of the whole deposit. The "G" indicates that the deposit probably contains more than 35 percent gravel.

The "thickness class" indicates a depth range which is related to the potential resource tonnage for each deposit. Four thickness class divisions have been established as shown in the legend for Map 1.

The smaller sets of letters, divided from each other by a horizontal line, follow the thickness class number. The upper series of letters identifies the geologic deposit type (the types are summarized with respect to their main geologic and extractive characteristics in Appendix D) and the lower series of letters identifies the main quality limitations that may be present in the deposit as discussed in the next section.

Texture Symbol

The Texture Symbol provides a more detailed assessment of the grain size distribution in deposits where samples were taken during field study. The data from which these symbols are derived have been plotted on grain size distribution graphs. The relative amounts of gravel, sand, and fines in the sampled material are shown graphically by the subdivision of a circle into proportional segments.

Other information shown on Map 1 includes all known sand and gravel pits. Pits are shown by a dot symbol and a number which refers to the pit descriptions given in Table 2. Each description notes the location of the pit and the estimated face height and gravel content.

MAP 2: SELECTED SAND AND GRAVEL RESOURCE AREAS

Map 2 is an interpretative map derived from an evaluation of the deposits shown on Map 1. The deposits identified on Map 2 are those which are considered to be important in ensuring an adequate resource base for the future.

All the selected sand and gravel resource areas are first delineated by geological boundaries and then classified into three levels of significance: primary, secondary and teritary. These areas are identified on Map 2 by different shading patterns. Each area of primary significance is given a deposit number and all such deposits are shown by a dark tone on Map 2.

**Selected Sand and Gravel Resource Areas of primary significance are not permanent, single, land use units. They represent areas in which a major resource is known to exist and may be reserved wholly or partially for extractive development and/or resource protection.**

Deposits of secondary significance are indicated by a light tone on Map 2. Although deposits of secondary significance are not considered to be the "best" resource areas, they may contain large quantities of sand and gravel and should be considered as part of the aggregate supply of the area.

Areas of tertiary significance are outlined on the map by a solid line, but have no tone. They are not considered to be important resource areas, because of their low available resources or because of possible difficulties in extraction. Such areas may be useful for local needs, but are unlikely to support large-scale development.

The process by which deposits are evaluated and selected involves the consideration of two sets of criteria. The main selection criteria are site specific, related to the characteristics of individual deposits. Factors such as deposit size, aggregate quality, and deposit location and setting are considered in the selection of those deposits best suited for extractive development. A second set of criteria involves the assessment of local aggregate resources in relation to the quality, quantity, and distribution of resources in the region in which the area is located. The intent of such a process of evaluation is to ensure the continuing availability of sufficient resources to meet possible future demands.

## SITE SPECIFIC CRITERIA

### Deposit Size

Ideally, selected deposits should contain available sand and gravel resources large enough to support a commercial pit operation using a stationary or portable processing plant. In practice, much smaller deposits may be of significant value depending on the overall reserves in

the rest of the municipality. Generally, deposits in Class 1, i.e. those thicker than 20 feet (6 m) and containing more than 35 percent coarse aggregate larger than the No. 4 (4.75 mm) sieve are considered to be most favourable for commercial development. Thinner deposits may be valuable in municipalities with low total resources.

Aggregate Quality

The limitations of natural aggregate for various uses result from variations in the lithology of the particles making up the deposit, and from variations in the size distribution of these particles.

Four indicators of the quality of aggregate may be included in the symbol for each deposit on Map 1. They are: Gravel content (G or S), fines (C), oversize (O) and lithology (L).

Three of the indicators deal with grain size distribution. The "gravel content", (G or S), indicates the suitability of aggregate for various uses. Deposits containing more than 35 percent coarse aggregate larger than the No. 4 (4.75 mm) sieve, and also a minimum of 20 percent larger than the 1 inch (25 mm) sieve, are considered to be favourable extractive sites, since this content is the minimum from which crushed products can be economically produced.

Excess "fines" (high silt and clay content) may severely limit the potential use of an aggregate. Fines content in excess of 10 percent may impede drainage in road sub-base aggregate and render it more susceptible to the effects of frost action. In asphalt aggregate, excess fines hinder the bonding of particles. Deposits known to have a high fines content are indicated by a "C" in the quality portion of the Deposit Symbol.

Deposits containing more than 20 percent oversize material (greater than 4 inches (10 cm) in diameter) may also have use limitations. The oversize component is unacceptable for all concrete aggregate and for road-building aggregate, so it must be either crushed or removed during processing. Deposits known to have an appreciable oversize component are indicated by an "O" in the quality portion of the Deposit Symbol.

The other indicator of the quality of an aggregate is "lithology". Just as the unique physical and chemical properties of bedrock formations determine their value for use as crushed rock, so do various lithologies of particles in a sand and gravel deposit determine its suitability for various uses. The presence of objectionable lithologies such as chert, siltstone, and shale, even in relatively small amounts, can result in a reduction in the quality of an aggregate, especially for high-quality uses. Similarly, high weathered, very porous and friable rock can restrict the quality of an aggregate. Deposits known to contain objectionable lithologies are indicated by an "L" in the quality component of the Deposit Symbol.

If the Deposit Symbol indicates either "C", "O", "L" or any combination, the quality of the deposit is considered to be reduced for some uses of the aggregate. No attempt has been made to quantify the degree of limitation imposed. Assessment of the four indicators is made from published data, from data contained in files of the Ontario Ministry of Transportation and Communications and the Engineering and Terrain Geology Section of the Ontario Geological Survey, and from field observations.

Analyses of unprocessed samples obtained from test holes or pits are plotted on grain size distribution graphs. On the graphs are the gradation specifiction envelopes for Ontario Ministry of Transportation and

Communications' products: Granular Base Course (G.B.C.) A, B, and C; Hot-Laid (H.L.) Asphalt Sand Nos. 1, 2, 3, 4 and 8; and concrete sand. By plotting the grading curves with respect to the specification envelopes, it can be determined how well the unprocessed sampled material meets the criteria for each product.

Location and Setting

The location and setting of a resource area has a direct influence on its value for possible extraction. The evaluation of a deposit's setting is made on the basis of natural and man-made features which may limit or prohibit extractive development.

First, the physical context of the deposit is considered. Deposits with some physical constraint on extractive development, such as thick overburden or high water table, are less valuable resource areas, because of the difficulties involved in resource recovery. Second, permanent man-made features, such as roads, railways powerlines, and housing developments which are built on a deposit, may prohibit its extraction. A quantitative assessment of these constraints can be made by measurement of their areal extent directly from the topographic maps. The area rendered unavailable by these features is shown for each resource area in Table 3.

The assessment of sand and gravel deposits with respect to local land use and to land ownership is an important component of the general evaluation process. These aspects of the evaluation process are not considered further in this report, but readers are encouraged to discuss them with personnel of the Ontario Ministry of Natural Resources' District Office.

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## APPENDIX C - GLOSSARY

ABRASION RESISTANCE: Tests such as the Los Angeles Abrasion Test are used to measure the ability of aggregate to resist crushing and pulverizing under conditions similar to those encountered in processing and use. Measuring resistance is an important component in the evaluation of the quality and prospective uses of aggregate. Hard, durable material is preferred for road building.

ABSORPTION CAPACITY: See Appendix E

AGGREGATE: Any hard, inert, construction material (sand, gravel, shells, slag, crushed stone or other mineral material) used for mixing in various-sized fragments with a cement or bituminous material to form concrete, mortar, etc., or used alone for road building or other construction. Synonyms include mineral aggregate and granular material.

ALKALI-AGGREGATE REACTION: A chemical reaction between the alkalis of portland cement and certain minerals found in rocks used for aggregate. Alkali-aggregate reactions are undesirable because they can cause expansion and cracking of concrete. Although perfectly suitable for building stone and asphalt applications, alkali-reactive aggregates should be avoided for concrete uses.

BLENDING: Required in cases of extreme coarseness, fineness, or other irregularities in the gradation of unprocessed aggregate. Blending is done with approved sand-sized aggregate in order to satisfy the gradation requirements of the material.

CLAST: An individual constituent, grain, or fragment of a sediment or rock, produced by the mechanical weathering of a larger rock mass. Synonyms include particle and fragment.

CRUSHABLE AGGREGATE: Unprocessed gravel containing a minimum of 35 percent coarse aggregate larger than the No. 4 sieve (4.75 mm) as well as a minimum of 20 percent greater than the 26.5 mm sieve.

DELETERIOUS LITHOLOGY: A general term used to designate those rock types which are chemically or physically unsuited for use as construction or road-building aggregates. Such lithologies as chert, shale, siltstone, and sandstone may deteriorate rapidly when exposed to traffic and other environmental conditions. Similarly, highly weathered, very porous and friable rock can restrict the quality of the aggregate.

DOLOSTONE: A carbonate sedimentary rock consisting chiefly of the mineral dolomite and containing relatively little calcite (dolostone is also known as dolomite).

DRIFT: A general term for all unconsolidated rock debris transported from one place and deposited in another; distinguished from underlying bedrock. In North America, glacial activity has been the dominant mode of transport and deposition of drift. Synonyms include overburden and surficial deposit.

DRUMLIN: A low, smoothly rounded, elongated hill, mound, or ridge composed of glacial materials. These landforms were deposited beneath an advancing ice sheet, and were shaped by its flow.

EOLIAN: Pertaining to the wind, especially with respect to landforms whose constituents were transported and deposited by wind activity. Sand dunes are an example of an eolian landform.

FINES: A general term used to describe the size fraction of an aggregate which passes (is finer than) the No. 200 mesh screen (0.075 mm). Also described informally as "dirt", these particles are in the silt and clay size range.

GNEISS: A coarse-textured metamorphic rock with the minerals arranged in parallel streaks or bands. Gneiss is relatively rich in feldspar. Other common minerals found in this rock include quartz, mica, amphibole and garnet.

GRADATION: The proportion of material of each particle size, or the frequency distribution of the various sizes which constitute a sediment. The strength, durability, permeability and stability of an aggregate depend to a great extent on its gradation. The size limits for different particles are as follows:

| | |
|---|---|
| Boulders | more than 200 mm |
| Cobbles | 75-200 mm |
| Coarse Gravel | 26.5-75 mm |
| Fine Gravel | 4.75-26.5 mm |
| Coarse Sand | 2-4.75 mm |
| Medium Sand | 0.425-2 mm |
| Fine Sand | 0.075-0.425 mm |
| Silt, Clay | less than 0.075 mm |

GRANITE: Is a coarse-grained light coloured rock that ordinarily has an even texture and is composed of quartz, and feldspar with either mica, hornblende or both.

GRANULAR BASE COURSE: Components of the pavement structure of a road, which are placed on the subgrade and are designed to provide strength, stability, and drainage, as well as support for surfacing materials. Several types have been defined: Granular Base Course A consists of crushed and processed aggregate and has relatively stringent quality standards in comparison to Granular Base Course B and C which are usually pit-run or other unprocessed aggregate.

HOT-LAID (OR ASPHALTIC) AGGREGATE: Bituminous, cemented aggregates used in the construction of pavements either as surface or bearing course (H.L. 1, 3, and 4), or as binder course (H.L. 2, 6, and 8) used to bind the surface course to the underlying granular base course.

LITHOLOGY: The description of rocks on the basis of such characteristics as colour, structure, mineral composition, and grain size. Generally, the description of the physical character of a rock.

MAGNESIUM SULPHATE SOUNDNESS TEST: See Appendix E

MELTWATER CHANNEL: A drainage way, often terraced, produced by water flowing away from a melting glacier margin.

PETROGRAPHIC EXAMINATION: See Appendix E

PLEISTOCENE: An epoch of the recent geological past including the time from approximately 2 million years ago to 7000 years ago. Much of the Pleistocene was characterized by extensive glacial activity and is popularly referred to as the "Great Ice Age".

POSSIBLE RESOURCE: Reserve estimates based largely on broad knowledge of the geologic character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on assumed continuity or repetition for which there are reasonable geological indications.

PRECAMBRIAN: The earliest subdivision of earth history extending from the consolidation of the earth's crust to the beginning of the Phanerozoic Era.

SOUNDNESS: The ability of the components of an aggregate to withstand the effects of various weathering processes and agents. Unsound lithologies are subject to disintegration caused by the expansion of absorbed solutions. This may seriously impair the performance of road-building and construction aggregates.

TILL: Unsorted and unstratified rock debris, deposited directly by glaciers, and ranging in size from clay to large boulders.

WISCONSINAN: Pertaining to the last glacial stage of the Pleistocene Epoch in North America. It began approximately 100 000 years ago and ended approximately 7000 years ago. The glacial deposits and landforms of Ontario are predominantly the result of glacial activity during the Wisconsinan Stage.

## APPENDIX D - GEOLOGY OF SAND AND GRAVEL DEPOSITS

The type, distribution, and extent of sand and gravel deposits in Ontario are the result of extensive glacial and glacially influenced activity in Wisconsinan time during the Pleistocene Epoch, aproximately 100 000 to 7000 years ago. The deposit types reflect the different depositional environments that exited during the melting and retreat of the continental ice masses, and they can readily be differentiated on the basis of their morphology, structure, and texture. The deposit types are described below.

### GLACIOFLUVIUAL DEPOSITS

These deposits can be divided into two broad categories: those that were formed in contact with (or in close proximity to) glacial ice, and those that were deposited by meltwaters carrying materials beyond the ice margin.

Ice-Contact Terraces (ICT): These are glaciofluvial features deposited between the glacial margin and a confining topographic high, usch as the side of avlley. The structure of the deposits may be similar to that of outwash deposits, but in most cases the sorting and grading of the material is more variable and the bedding is discontinuous due to extensive slumping. The probability of locating large amounts of crushable aggregate is moderate, and extraction may be expensive due to the variability of the deposits both in terms of quality and grain size distribution.

Kames (K): Kames are defined as mounds of poorly sorted sand and gravel deposited by meltwater in depressions or fissures on the ice surface or at its margin. During glacial retreat, the melting of supporting ice causes collapse of the deposits, producing internal structures characterized by bedding discontinuities. The deposits consist mainly of irregularly bedded and crossbedded, poorly sorted sand and gravel. The

present forms of the deposits include single mounds, linear ridges (crevasse fillings) or complex groups of landforms. The latter are occasionally described as "undifferentiated ice-contact stratified drift" (IC) when detailed subsurface information is unavailable. Since kames commonly contain large amounts of fine-grained material and are characterized by considerable variability, there is generally a low to moderate probability of discovering large amounts of good quality, crushable aggregate. Extractive problems encountered in these deposits are mainly the excessive variability of the aggregate and the presence of excess fines (silt- and clay-sized particles).

Eskers (E): Eskers are narrow, sinuous ridges of sand and gravel deposited by meltwaters flowing in tunnels within or at the base of glaciers, or in channels on the ice surface. Eskers vary greatly in size. Many, though not all eskers consist of a central core of poorly sorted and stratified gravel characterized by a wide range in grain size. The core material is often draped on its flanks by better sorted and stratified sand and gravel. The deposits have a high probability of containing a large proportion of crushable aggregate, and since they are generally built above the surrounding ground surface, are convenient extraction sites. For these reasons esker deposits have been traditional aggregate sources throughout Ontario, and are significant components of the total resources of many areas.

Some planning constraints and opportunities are inherent in the nature of the deposits. Because of their linear nature, the deposits commonly extend across several property boundaries leading to unorganized extractive development at numerous small pits. On the other hand, because of their form, eskers can be easily and inexpensively extracted and are amenable to rehabilitation and sequential land use.

Undifferentiated Ice-Contact Stratified Drift (IC): This designation may include deposits from several ice-contact, depositional environments which usually form extensive, complex landforms. It is not feasible to identify individual areas of coarse-grained material within such deposits because of their lack of continuity and grain size variability. They are given a qualitative rating based on existing pit and other subsurface data.

Outwash (OW): Outwash deposits consist of sand and gravel laid down by meltwaters beyond the margin of the glacier. The deposits occur as sheets or as terraced valley fills (valley trains) and may be very large in extent and thickness. Well developed outwash deposits have good horizontal bedding and are uniform in grain size distribution. Outwash deposited near the glacier's margin is much more variable in texture and structure. The probability of locating useful crushable aggregates in outwash deposits is moderate to high depending on how much information on size, distribution and thickness is available.

Alluvium (AL): Alluvium is a general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during postglacial time by a stream as sorted or semi-sorted sediment, on its bed or on its floodplain. The probability of locating large amounts of crushable aggregate in alluvial deposits is low, and it has generally low value due to the presence of excess silt- and clay-sized material. There are no large postglacial alluvium deposits in Ontario.

GLACIOLACUSTRINE DEPOSITS

Glaciolacustrine Beach Deposits (LB): These features are formed by wave action at the shores of glacial lakes that existed at various times during the deglaciation of Ontario. Well developed lacustrine beaches are usually less than 20 feet (6 m) thick. The aggregate is well sorted and stratified and sand-sized material commonly predominates. The composition and size

distribution of the deposit depends on the nature of the underlying material. The probability of obtaining crushable aggregate is high when the material is developed from coarse-grained materials such as a stony till, and low when developed from fine-grained materials.

Glaciolacustrine Deltas (LD): These features were formed where streams or rivers of glacial meltwater flowed into lakes and deposited their suspended sediment. In Ontario such deposits tend to consist mainly of sand and abundant silt. However, in near-ice and ice-contact positions, coarse material may be present.

Glaciolacustrine Plain (LP): The nearly level surface marking the floor of an extinct glacial lake. The sediments which form the plain are predominantly fine to medium sand, silt, and clay, and were deposited in relatively deep water. Lacustrine deposits are generally of low value as aggregate sources due to their fine grain size and lack of crushable material. In some aggregate-poor areas, lacustrine deposits may constitute valuable sources of fill and some granular base course aggregate.

GLACIAL DEPOSITS

End Moraines (EM): These are belts of glacial drift deposited at, and parallel to, glacier margins. They commonly consist of ice-contact stratified drift and in such instances are usually called kame moraines. Kame moraines commonly result from deposition between two glacial lobes (interlobate moraines). The probability of locating aggregates within such features is moderate to low. Exploration and development costs are high. Moraines may be very large and contain vast aggregate resources, but the location of the best areas within the moraine is usually poorly defined.

EOLIAN DEPOSITS

Windblown Deposits (WD): Windblown deposits are those formed by the transport and deposition of sand by winds. The form of the deposits ranges from extensive, thin layers to well developed linear and crescentic ridges known as dunes. Most windblown deposits in Ontario are derived from, and deposited on, pre-existing lacustrine sand plain deposits. Windblown sediments are almost invariably composed of fine to coarse sand and are usually well sorted. The probability of locating crushable aggregate in windblown deposits is very low.

## APPENDIX E - AGGREGATE QUALITY TEST DATA

Three types of aggregate quality tests have been performed on selected samples from the project area. The results of these tests (Tables E1 & E2) along with a description and the specification limits for each test are included in this appendix. Although a specific sample meets or does not meet the specification limits for a certain product, it may or may not be acceptable for that use based on field performance. Additional quality tests other than the three major tests listed in this appendix can be used to determine the suitability of an aggregate. The above three types of tests were performed by the Soils and Aggregate Section, Engineering Materials Office, Ontario Ministry of Transportation and Communications.

ABSORPTION CAPACITY: Related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate.

MAGNESIUM SULPHATE SOUNDNESS TEST: This test is designed to simulate the action of freezing and thawing on aggregate. Those aggregates which are susceptible will usually break down and give high losses in this test.

PETROGRAPHIC EXAMINATION: An aggregate quality test based on known field performance of various rock types. The test result is a Petrographic Number (P.N.). The higher the P.N. the lower the quality of aggregate.

TABLE E-1:

## SELECTED QUALITY REQUIREMENTS FOR MAJOR AGGREGATE PRODUCTS

| TYPE OF MATERIAL \ TYPE OF TEST | COARSE AGGREGATE | | | FINE AGGREGATE |
|---|---|---|---|---|
| | PETROGRAPHIC NUMBER MAXIMUM | MAGNESIUM SULPHATE SOUNDNESS-MAX.% LOSS | ABSORPTION MAXIMUM % | MAGNESIUM SULPHATE SOUNDNESS MAXIMUM % LOSS |
| GRANULAR BASE A | 200 | - | - | - |
| 16mm CRUSHED TYPE 'A' | 160 | - | - | - |
| 16mm CRUSHED TYPE 'B' | 200 | - | - | - |
| GRANULAR SUBBASE B | 250 | - | - | - |
| GRANULAR SUBBASE C | 250 | - | - | - |
| GRANULAR SUBBASE D | - | - | - | - |
| HOT MIX - H. L. 1 | 100 | 5 | 1.0 | 16 |
| HOT MIX - H. L. 2 | - | - | - | 20 |
| HOT MIX - H. L. 3 | 135 | 12 | 1.75 | 16 |
| HOT MIX - H. L. 4 | 160 | 12 | 2.0 | 20 |
| HOT MIX - H. L. 8 | 160 | 15 | 2.0 | 20 |
| STRUCTURAL CONCRETE AND CONCRETE BASE | 140 | 12 | 2.0 | 16 |
| PAVEMENT CONCRETE AND EXPOSED STRUCTURE DECK | 125 | 12 | 2.0 | 16 |

( M.T.C. Forms 1002, 1003 and 1010 )

Table E-2: Aggregate Quality Test Results, Opapimiskan Lake Area

| SAMPLE NO. | COARSE AGGREGATE | | | | FINE AGGREGATE |
|---|---|---|---|---|---|
| | PETROGRAPHIC NUMBER | | MAGNESIUM SULPHATE SOUNDNESS | ABSORPTION | MAGNESIUM SULPHATE SOUNDNESS |
| | GRANULAR & 16mm CRUSHED | HOT MIX & CONCRETE | | | |
| OP-SS-1 | 104 | 118 | 2 | .668 | 10.9 |
| Pit 6 | 102 | 111 | 1 | .534 | 7.9 |
| Pit 10 | 101 | 108 | 1 | .534 | 8.3 |
| OP-SS-12 | 104 | 109 | 1 | .601 | 9.4 |
| Pit 15 | 101 | 109 | 2 | .534 | 8.2 |

NOTE : The quality refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be excercised in extrapolating such information to the rest of the deposit.

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# MAPS NOT FILMED

# CARTES OMISES